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PM FEATURES //

VOL. 188 NO. 3

50 Blue Sky Power

Big-bucks investors (including Google) are gambling tens of millions of dollars on a potentially game-changing new energy source: airborne wind turbines. The technology is revolutionary, but can it really turn a steady breeze into a paying proposition?

BY JAMES VLAHOS

58 We Build a Shop PC

Our editors set out to create a garage-rocking computer that can stand up to metal dust, oil drips, flying wrenches and more. The result is a fully capable, crushingly powerful machine of technical beauty.

BY GLENN DERENE

72 Cutting Class

After a fire destroyed a Dartmouth College canoe club's historic log cabin retreat, a group of students rallied to restore it—the old-fashioned way. Here's how they combined chain-saw carpentry with 4.0 smarts to build a classic structure.

BY JIM COLLINS

76 Detroit vs the World

Previously outmatched by overseas rivals, domestic carmakers are now brimming with high-performing, stylish models. We pit the best new Ford, GM and Chrysler autos against top foreign marques in the ultimate road test. May the best cars win!

BY BEN STEWART

64

Down in the Hole

America's 1960s-era intercontinental ballistic missile facilities are due to close by 2030. How will the Air Force keep this vital defense system working? PM descends into a Malmstrom Air Force Base bunker in Montana to find out.

BY JOE PAPPALARDO

FOR TRAINING ONLY

An Air Force maintenance technician trains on a 60-foot-tall mockup of the Minuteman III nuclear missile. The real deal can deliver up to three 350-kiloton nuclear warheads anywhere in 30 minutes.

ON THE COVER

Wind power is already a proven source of renewable energy. Now, a new frontier is opening up: flying, megawatt-producing wind turbines. Illustration by Bluddy (environment) and Michael Tschernajew (turbines); composition by A.J. Verducci.

NEW CARS

35 Italian Renaissance

Little car, big splash: Fiat returns to the U.S. market with the pint-size but spirited 500. **PLUS** We decode the Chevy Volt's EPA fuel-economy sticker and find out how a hybrid Honda race car fares on the track.

Popular Mechanics

PM DEPARTMENTS

NEW TOOLS / CARS / HOME / HOW-TO

diy

pm do-it-yourself

HOME

85 Double Duty

Want to green up your yard without a labor-intensive full-size garden? Build our trellis planter for a simple, fun way to get growing.

92 Homeowners Clinic

Bathroom refresher: Regrout tile in six simple steps. **PLUS** Replacing glass panes in a steel door; how to make working in a crawlspace just a bit less hellish.

98 PM Saturday

Is it a portable tool kit? Is it a tiny workbench? Hey, it's both! Build PM's fold-out, suitcase-style workbox.

AUTO

100 Saturday Mechanic

Increase the durability and foot traction of your truck's bed with our easy and inexpensive DIY lining project.

102 Car Clinic

Is the 3000-mile oil change really necessary? **PLUS** The delicate task of fixing an airbag; how to make a big ol' Chevy van roll a little freer.

TECH

108 Start a Web Business

Jobs may be scarce, but starting your own online business has never been easier. PM tells you how to take your idea from concept all the way to *cha-ching*.

110 Digital Clinic

Making room in your home for Microsoft Kinect. **PLUS** Reclaiming the iPad's orientation lock; the new Facebook Messages auto-reply feature.

TECH WATCH

13 New Wheels for Off-Planet Rides

NASA and Goodyear build an extra-tough tire to keep vehicles rolling on rocky alien landscapes. **PLUS** The Evel Knievel of stuntmen, Hal Needham, recounts some of his death-defying moves.

UPGRADE

23 Star Search

Celestron's SkyProdigy 130 automatic telescope focuses quickly, costs less. **PLUS** We put the pressure on titanium nitride drill bits in our latest Abusive Lab Test; we see the future of 3D TV—and thankfully, it's glasses-free.

COLUMNS

46 Long-Term Test Cars

The economical and agile Mazda2 Touring joins our fleet. **PLUS** The secret device that keeps the BMW X5's diesel humming; we bid adieu (sniff, sniff) to our beloved Nissan 370Z Roadster.

IN EVERY ISSUE

How to Reach Us 8 / Letters 10 / This Is My Job 120

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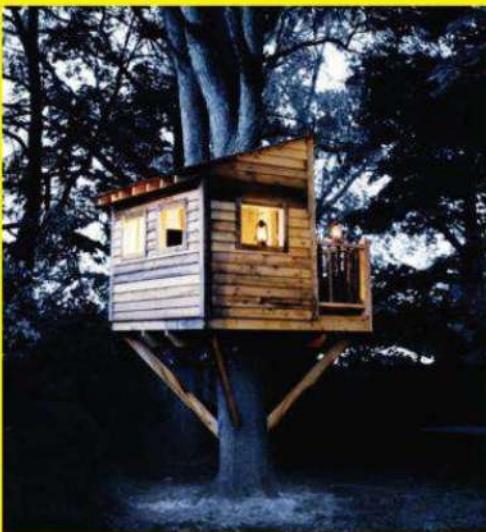
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A Heated Topic

Loved January's wood-heating article ("Introducing the High-Tech, Cutting-Edge, Carbon-Neutral, Alternative Fuel of the Future: Wood"). Right to the point, just the facts, brilliant graphics—it's exactly what I've come to expect from POPULAR MECHANICS. I recently replaced an old, polluting stove with an EPA-approved soapstone one. It's a great stove, but it requires a lot of getting used to. While our old unit burned just about anything (even green wood), our new high-efficiency stove is more finicky about what we're able to burn in it. The change is good, but not without challenge!

CASEY LISTON
SILK HOPE, NC

I enjoyed your comparisons of wood, pellet and masonry stoves against other forms of heating, but wish you would have also included wood-fired gasification boilers. The system allows for a higher amount of oxygen and a more complete combustion of wood fuel. It's perhaps the most efficient system for extracting energy from wood.

ERIC A. REYNOLDS
CLYDE, NY

How could you leave geothermal out of the discussion? Besides the initial installation cost, which is significantly offset by federal and state incentives, geothermal operates at a significantly lower cost. These systems are a truly green energy source and are basically maintenance-free.

SAM HESS
ROCHESTER, NY

I recently built a house and installed a heat pump (with electric heat strips as backup)



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Roger
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holds a
recent issue
during his
visit to the
Great Wall
of China, a
long way
from his
home in
Bolingbrook,
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Jan.

ISSUE
01 / 11
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Readers share their thoughts on our stories about heating homes with wood and the future of the flying car.

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and a wood stove. Generally, I run my heat pump until temperatures outside dip below 20 degrees. Then I switch to the wood stove to avoid using the costly electric strips. I wonder how the efficiency of my system compares to others?

BILL STILLMAN
ROSE, OK

Flying Into the Future
As an intellectual exercise, your article "Driving on Air" is quite interesting. But having spent 35 years as a commercial helicopter pilot, I shudder to think of a sky filled with everyday commuters whizzing through the air around me.

Before we get too wrapped up in "could we," perhaps we should devote some time to "should we" for safety's sake. These machines would operate at low altitudes that are already crowded enough.

LARRY BOLES
GRANBURY, TX

CORRECTIONS: In January's Tech Watch, the photo credit for the laser scan in "Reverse-Engineered Blueprints" (page 9) should read "Photograph courtesy of Harry R. Feldman, Inc." In the "How to Heat a House" chart (page 59), "Electric Heat Pump" should read "Electric Heat."

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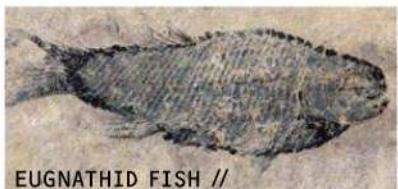
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New ecosystem? It'll take 10 million years.

→ An international team of paleontologists in China uncovered a trove of 20,000 aquatic fossils that detail how life

rebounded after a mass extinction, caused in part by climatic changes after multiple volcanoes erupted 250 million years ago. Only one of every 10 species on the planet survived that event, but these were enough to restart fully functional ecosystems that had diverse kinds of large predators.



EUGNATHID FISH //

• QUICK HITS

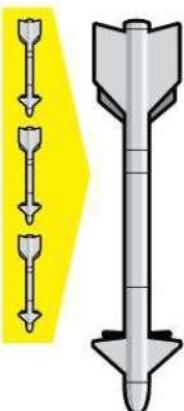


MANUFACTURING MIRACLE FABRIC

→ Researchers see great promise in cloth that releases medicine exactly when needed, used in uniforms imbued with antidotes to chemical weapons or as gauze infused with tissue-regenerating salves to heal burn victims. Manufacturing the hollow, nanoscale forms that contain the medicine, however, is problematic. The U.S. National Institute of Standards and Technology is funding Massachusetts-based Arsenal Medical's research into a new way to make these fabrics at an industrial scale. The company will use electrical fields to shape polymeric droplets into nanotubes or

mesh, intertwining the medicine inside the fibers. These would replace the current system, which uses tiny needles to inject substances into hollow fibers.

ONE MISSILE, THREE JOBS
→ DARPA has tapped Raytheon and Boeing (for \$21.3 million each) to create the Triple Target Terminator, a missile that can adjust its speed, explosive yield and sensors to attack ground targets, airplanes or cruise missiles. Flight demonstrations are planned for 2014.



Tech Watch



• VEHICLE DESIGN

New Wheels for Off-Planet Rides

Future robotic missions to the moon could require heavy vehicles that can range over thousands of miles of extraterrestrial landscapes—demands that would overwhelm the wire-mesh wheels used on Apollo-era buggies, none of which traveled more than 22 miles. NASA and Goodyear Tire recently teamed up to develop a tire made of 800 independent springs, any of which can fail without compromising the rest of the tire. Engineers tested the design on NASA's Lunar Electric Rover over rocky terrain at Johnson Space Center in Houston. Goodyear hopes the tough, airless tires generate interest from fire departments, mine owners and other operators of indispensable wheeled vehicles. —ALEX HUTCHINSON



• REACHING ORBIT

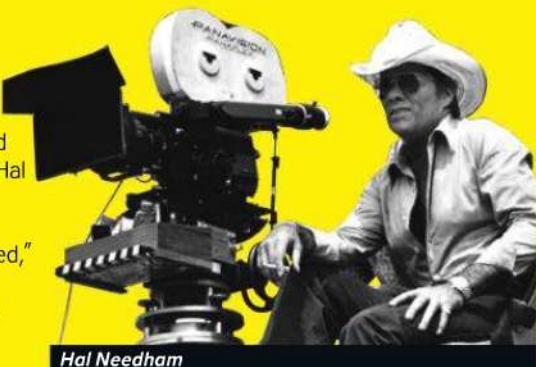
Private Space Breakthrough

→ Space Exploration Technologies (SpaceX) last December became the first private firm to recover a spacecraft from Earth's orbit. The launch is part of a NASA program looking at the private sector to resupply the International Space Station once the space shuttle retires this year. SpaceX's capsule, Dragon, circled the Earth and landed in the Pacific Ocean 500 miles west of California.

ENTERTAINING DANGER

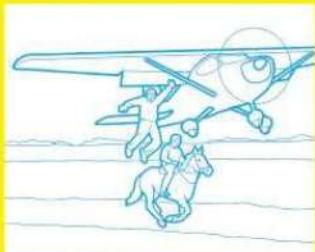
Stunt Master

Decades before directors relied on CGI to create action sequences, exceptionally brave stuntmen and -women performed every extreme act themselves. And none were quite so brave as Hal Needham, who appeared in thousands of TV episodes and films, doubling for icons including Kirk Douglas and Charles Bronson. "There's no such thing as a great stunt if there's no danger involved," the 80-year-old legend says. In honor of his memoir, *Stuntman! My Car-Crashing, Plane-Jumping, Bone-Breaking, Death-Defying Hollywood Life*, on shelves in February, Needham walks POPULAR MECHANICS through his favorite stunts. — BEN STEWART



Hal Needham

HAL NEEDHAM'S MOST EPIC STUNTS


You Asked for It
(1950–1959)

This TV stunt called for Needham to jump off a flying plane and tackle a man riding a horse. The pilot—flying at 58 mph, 18 feet above the ground—kept the plane from stalling by pointing the nose upward. Needham used hand signals to help the pilot get into position, then let go and sailed 20 feet through the air, safely tackling the rider.


Little Big Man
(1970)

In this film sequence, Needham leapt from galloping horses onto a stagecoach, then did a series of 14-foot standing broad jumps from the bare backs of one stagecoach horse to the next. "We used the momentum of the horses to propel us," Needham says. "As the horse pushed off his back legs, you jumped."


Gator
(1976)

Doubling for Burt Reynolds, Needham had to leap from a rolling pickup traveling at 55 mph. As he sailed through the air, Needham saw the truck was coming down even with his body. The truck turned over sideways and crashed down next to Needham—missing him by 2 feet. "Had it gone straight, it would have landed on me," he says.

PM UPDATE Secret Space Plane Lands


In an early-morning touchdown in December, the Air Force's X-37B unmanned spacecraft (see "Return of the Space Plane," May 2010) fired its maneuvering engine to put itself into position for an autonomous landing at California's Vandenberg Air Force Base. The X-37B had just completed its inaugural, 220-plus-day mission in orbit. The Air Force is not saying what experiments the X-37B conducted, but satellite watchers and defense wonks say its shifting orbits indicate the vehicle was being tested as a reconnaissance platform that could launch quickly and move around in space to monitor multiple targets at unpredictable times. A second mission is planned for spring 2011.

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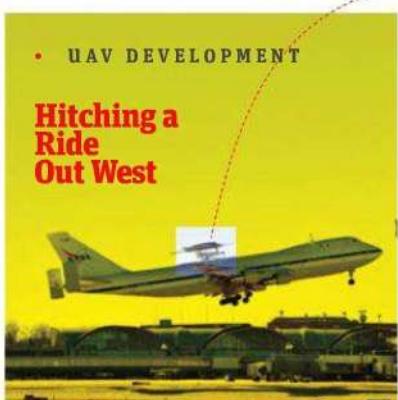


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It doesn't really count as a first flight, but late last year, Boeing's Phantom Ray, an unmanned stealth aircraft, got a lift on the back of a 747 airliner that NASA had converted to carry the space shuttle. The Phantom Ray traveled from St. Louis to California, where staff at Dryden Flight Research Center will conduct test flights. Boeing is developing the Phantom Ray with its own funds in order to keep pace with Northrop Grumman's Navy-funded UAV program.

TECH CULTURE



◀ Michelle Rodriguez as Air Force tech sergeant Santos in *Battle: Los Angeles*.

An Officer and an Alien

What if all the UFO sightings over the years weren't weather balloons or secret military planes, but alien scout craft doing reconnaissance for a future invasion? That's the premise of *Battle: Los Angeles*, an on-the-ground view of a worldwide invasion from the perspective of one squad of Marines. It opens March 11. "It's like *District 9* meets *Black Hawk Down* meets *Modern Warfare*," says star Michelle Rodriguez (*Avatar*). "That's the best way to explain it."

Director Jonathan Liebesman wanted his actors to bring realism to their portrayal of Marines, so his crew contacted Lt. Col. Jason Johnston,

artilleryman turned director of the Marine Corps Entertainment Office in Los Angeles. The office handles requests from productions that want the support of the Corps, which includes everything from providing reference recordings for video games to scheduling a production's use of assets such as helicopters. Johnston and his crew looked over the script, advised the prop and costume departments and subjected the actors to a three-week boot camp: Like real Marines, the cast slept outside, participated in physical training, learned tactics and hit the gun range.

But while the actors' Marine guise was nearly perfect, not everything in *Battle: Los Angeles* hits that same standard of accuracy. Rodriguez, who sat down with Air Force techs in the Intelligence, Surveillance and Reconnaissance Division to research her role, says some of the technical information her character imparts was simplified for the benefit of the audience. One character, for example, asks if radio-frequency transmissions could take out electronics. "I said yeah, because I was supposed to, but that's not right—electromagnetic pulses [EMPs] are what do that!" Rodriguez says. "Producers think that people don't get it, but kids who play video games know what EMPs are. But I'm aware that it's a film, so I have to say, let it go, Michelle." —ERIN MCCARTHY

MARINES VS. ALIENS



The aliens rely on large unmanned attack aircraft to soften human resistance; real-life Marine squads launch handheld UAVs to see surrounding terrain.

SEA



Expeditionary warfare depends on supporting ground troops from areas away from combat. Marines use large surface ships; the alien equivalents emerge from underwater—and underground.

LAND



Alien foot soldiers face an experienced foe in the streets of L.A.; the U.S. Marines' first urban fight occurred in Tripoli in 1805.

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EVERYDAY PHYSICS

Secrets of a Dry Dog

With a few brisk shakes, wet dogs can remove about half the water from their fur. Inspired by this behavior, a team of engineers at the Georgia Institute of Technology, led by assistant professor David Hu, is studying the drying behavior of canines and other mammals in order to mimic their efficiency: A washing machine's spin cycle takes about 10 minutes of constant spinning to remove approximately the same percentage of moisture. Hu and his team are working with washing-machine manufacturers such as Whirlpool to instill dog-like snapping motions into everyday appliances. — KATHRYN KENNEDY



The average radius of a Labrador retriever's abdomen is about 5 inches. How fast a dog must shake to become dry depends on the radius of its cylindrical abdomen. The larger the radius, the lower the frequency at which the pooch has to shake.

Labrador retrievers shake at their optimal frequency—4.5 Hz—in order to get dry.
Canines instinctively shake at a high enough frequency to enable centripetal force to overcome the surface tension keeping water droplets on their fur.

Dogs rotate their spines about 30 degrees with each twist.
Their loose skin continues to move, however, allowing for a total oscillation of about 100 degrees in each direction, providing extra force to eject water droplets from fur.



IN THEIR OWN WORDS

Woodie Flowers

Professor emeritus, MIT

Woodie Flowers thinks the best use of a robot is to get teens excited about engineering. Since its inception in 1992, he has advised inventor Dean Kamen's FIRST (For Inspiration and Recognition of Science and Technology) Robotics Competition, a league for students who design robots that race through obstacle courses. — ERIK SOFGE

PM: *How do FIRST robots today compare with those in the early competitions?*

WF: When I first started, it was paper clips and rubber bands. Now it's super-powerful processors and rapid prototyping.

PM: *Kamen has always said that FIRST events should be televised.*

WF: If our goal is to get on television, I'm out. If our goal is for more people to know about FIRST and be positive about it, I'm in. Right now, television on the whole represents many things that I don't respect.

PM: *How have robots changed the lives of participants?*

WF: The really interesting stories have to do with the people: the kids from New York City who built their robot out of plywood and qualified for the nationals; gang members who became college students because of FIRST. The robots are a wonderful and demanding project that makes all of that happen.



**"Sis, you wrote your doctor said you've
got plaque in your heart's arteries.
Well, here's something you need to read."**

This Intervention Brought to You by NIASPAN.

- If you have high cholesterol and coronary artery disease, NIASPAN, along with diet and a bile acid-binding resin (another cholesterol medicine), is FDA-approved not only to slow down plaque buildup, but to actually help clear some of it away.
- A low-fat diet and exercise alone may not be enough.

High cholesterol is one risk factor that leads to plaque buildup. Other factors include: family history of early heart disease, high blood pressure, smoking, and diabetes.

NIASPAN, with a bile acid-binding resin, has not been shown to prevent heart disease, heart attacks, or stroke.

IMPORTANT SAFETY INFORMATION

- Prescription NIASPAN should not be taken by people with stomach ulcers, liver, or serious bleeding problems. ■ Severe liver damage can occur when switching to a long-acting niacin, such as NIASPAN, from immediate-release niacin.
- Blood tests are needed before and during treatment with NIASPAN to check for liver problems. ■ Contact a health care provider if serious side effects such as unexplained muscle pain, tenderness, or weakness develop. ■ The risk of these side effects may be higher when lovastatin or simvastatin are taken with NIASPAN. ■ Tell your health care provider if you have a history of gout, drink large amounts of alcohol, or if you are diabetic and experience increases in blood sugar. ■ The most common side effect of NIASPAN is flushing (warmth, redness, itching, and/or tingling of the skin).

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088 (1-800-332-1088).

If you cannot afford your medication, contact: www.pparx.org or call the toll-free number 1-888-4PPA-NOW (1-888-477-2669) for assistance.

Please see the next page for brief summary of full Prescribing Information.



START FIGHTING PLAQUE.
ASK YOUR DOCTOR ABOUT NIASPAN.

Fight Back. Fight Plaque.



1-877-NIASPAN (1-877-642-7726)

www.niaspan.com

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NIASPAN® (ny-a-span) (niacin extended-release tablets)

CONSUMER BRIEF SUMMARY
CONSULT PACKAGE INSERT FOR FULL
PRESCRIBING INFORMATION

IMPORTANT INFORMATION ABOUT NIASPAN® (niacin extended-release tablets)¹

What is NIASPAN?

NIASPAN is a prescription medication used along with diet in people who cannot control their cholesterol levels by diet and exercise alone.

NIASPAN is used to increase good (HDL) cholesterol and lower bad (LDL) cholesterol and triglycerides in people with abnormal cholesterol levels.

NIASPAN can be used in combination with lovastatin or simvastatin to improve cholesterol levels when taking NIASPAN, simvastatin or lovastatin alone is not enough. NIASPAN is used to lower the risk of heart attack in people who have had a heart attack and have high cholesterol.

NIASPAN can be used in combination with a bile acid binding resin (another cholesterol medicine) to slow down or lessen plaque build-up in people with coronary artery disease and high cholesterol.

No additional benefit of NIASPAN on heart disease has been demonstrated when used with simvastatin or lovastatin over and above that shown for niacin, simvastatin or lovastatin when used alone.

Who should not take NIASPAN?

Anyone who has stomach ulcers, liver problems, serious bleeding disorders, or is allergic to any product ingredient.

What should I tell my doctor before taking NIASPAN?

Tell your doctor about any other medications, vitamins, or nutritional supplements you are taking including any that contain niacin or nicotinamide.

It is especially important to tell your doctor if you take:

- Other medicines to lower cholesterol or triglycerides
- Aspirin
- Blood pressure medications
- Blood thinner medications

Tell your doctor if you:

- Have a history of stomach ulcers, liver or kidney problems, serious bleeding problems, or gout
- Have drug allergies
- Have diabetes
- Are pregnant or may become pregnant
- Are breast-feeding
- Consume large amounts of alcohol

What are the possible side effects of NIASPAN?

All forms of niacin are not the same as NIASPAN. Do not switch between forms of niacin without first talking to your doctor as severe liver damage can occur.

Tell your doctor about any unexplained muscle pain, tenderness, or weakness, as this could be a sign of a rare but serious side effect. This risk may be increased when NIASPAN is taken with a statin.

NIASPAN is associated with increases in liver enzymes measured by blood tests. Your doctor should do blood tests before and during treatment with NIASPAN to check for liver problems.

NIASPAN may cause an increase in blood sugar levels. Diabetics should carefully check your blood sugar levels especially during the first few months of NIASPAN and during any change in your NIASPAN dose. Report any changes in blood sugar levels to your doctor.

Tell your doctor if you have a history of gout. NIASPAN may cause an increase in uric acid levels.

The most common side effects are flushing, rash, diarrhea, nausea, vomiting, increased cough, and itching.

Flushing:

Flushing (warmth, redness, itching and/or tingling of the skin) is a common side effect of NIASPAN therapy that may subside after several weeks of consistent NIASPAN use. Flushing may vary in severity and is more likely to occur with initiation of therapy or during dose increases. By dosing at bedtime, flushing will most likely occur during sleep. However, if awakened by flushing at night, you should get up slowly, especially if feeling dizzy, feeling faint, or taking blood pressure medications.

- Taking aspirin (up to the recommended dose of 325 mg) about 30 minutes before taking NIASPAN, as directed by a doctor, may help manage flushing.
- Do not drink hot or alcoholic beverages and spicy foods around the time of taking NIASPAN to help minimize flushing.
- Take NIASPAN with a low-fat snack at bedtime to help lessen upset stomach.

People with high cholesterol and heart disease are at risk for a heart attack. Symptoms of a heart attack may be different from a flushing reaction from NIASPAN. The following may be symptoms of a heart attack due to heart disease and not a flushing reaction:

- Chest pain

- pain in other areas of your upper body such as one or both arms, back, neck, jaw or stomach
- shortness of breath
- sweating
- nausea
- lightheadedness

The chest pain you have with a heart attack may feel like uncomfortable pressure, squeezing, fullness or pain that lasts more than a few minutes, or that goes away and comes back. Heart attacks may be sudden and intense, but often start slowly, with mild pain or discomfort.

Call your doctor right away if you have any symptoms of a heart attack.

This safety information does not include all of the information people should know before taking NIASPAN. For a complete list of side effects, ask your doctor.

General information about NIASPAN

Do not use NIASPAN for a condition for which it was not prescribed. Do not give NIASPAN to other people, even if they have the same condition you have. This leaflet summarizes important information about NIASPAN. If you would like more information, talk to your doctor.

For more information or a copy of full Prescribing Information call Abbott at 1-888-5-NIASPAN (1-888-564-2772) or visit www.niaspan.com.

Niaspan is a registered trademark of Abbott Laboratories

Reference: 1. Niaspan [package insert]. North Chicago, IL: Abbott Laboratories.

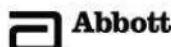
Manufactured for Abbott Laboratories, North Chicago, IL 60064, U.S.A.

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Norwich, NY 13815
or

500 mg, 750 mg and 1000 mg tablets
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Barceloneta, PR 00617
Ref. 03-A432-Revised December, 2010

303-491526 MASTER

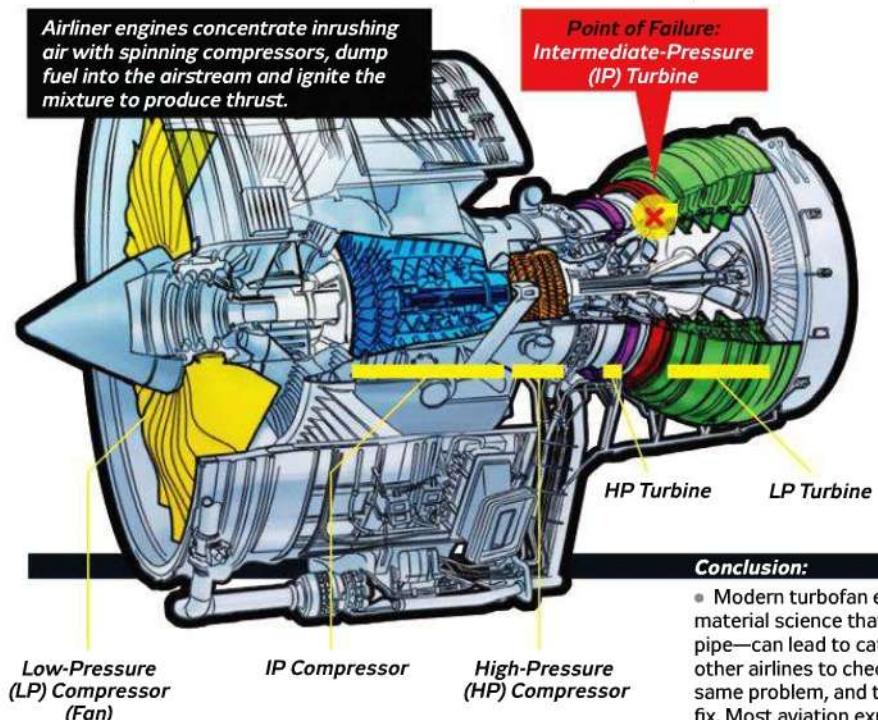
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WHAT WENT WRONG

Airbus Engine Explosion

Last November, an engine on a Qantas A380 taking off from Singapore exploded. Shards of metal burst out of the massive cowling, punching holes in the wing and fuselage, severing wires and shredding fuel and hydraulic lines. By a stroke of luck, two additional A380 pilots happened to be on board, and they helped the captain and his two officers struggle for an hour and a half to cope with the aftermath of the uncontained engine failure. The team managed to get the airliner and its 469 passengers and crew safely back on the ground, averting what could have been the third-deadliest aviation accident in history.

**Stub Pipe**

- A tube that carries oil to lubricate bearings. The pipe in the Airbus's engine was poorly made; one of its walls was too thin. Subjected to engine vibration, it eventually cracked, leaking oil.

Bearing-Structure Buffer Space

- The gap between rotating discs and the assembly supporting them.

The flammable oil sprayed between the bearing and the turbine discs, one of the hottest parts of the engine.

Intermediate-Pressure (IP) Turbine Disc

- The power to turn the compressor blades comes from this spinning disc. The IP disc is designed to handle extreme temperatures, but when the leaking oil caught fire within the buffer space, its metal heated past the failure point.

Turbine Blades

- Long, thin edges that rotate in the stream of hot gases exiting the engine. Spinning at several thousand revolutions per minute, the blades' tips moved as fast as bullets. When the IP disc failed, the blades flew apart in a spray of shrapnel, nearly destroying the airliner.

Conclusion:

- Modern turbofan engines operate so close to the limits of material science that a single small flaw—in this case, in an oil pipe—can lead to catastrophic failure. European regulators required other airlines to check their Rolls-Royce Trent 900 engines for the same problem, and the company says its engineers have devised a fix. Most aviation experts expect no similar failures. —JEFF WISE

MODERN MEDICINE

Cure for Aging?

RESEARCHERS AT DANA-FARBER CANCER INSTITUTE IN MASSACHUSETTS HAVE REVERSED PHYSICAL AND MENTAL SIGNS OF AGE IN MICE BY SWITCHING ON A GENE. —A.H.

How does it work?

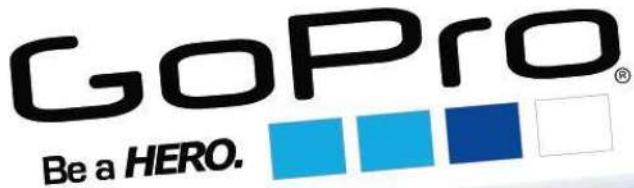
Every time an organism's cells divide and replicate, protective caps on the tips of the DNA strands called telomeres get shorter. When they are too short, the cells stop dividing—which researchers have found to be a key cause of aging. An enzyme called telomerase helps elongate the telomeres.

What was the experiment?

The scientists genetically engineered mice to keep the telomerase dormant, essentially causing them to age faster. But when researchers exposed these mice to a drug that activated the telomerase, the symptoms of aging reversed.

Will it work for people?

Applying results to humans will be a challenge, since too much telomerase may trigger cancer cell growth. The best bet for longevity is exercise: University of Colorado at Boulder researchers reported last year that the telomeres in runners past their 50s were as long as those found in people in their 20s.



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Upgrade

Star Search

→ Here's the dirty little secret—or rather, secrets—of most "automatically aligning" telescopes: Not only are their price tags, um, astronomical, but using the devices can also be a hassle. First, you input a set of data points, including the date, the time, your location and your target's coordinates; then you sit around for as long as 10 minutes while the scope zeroes in on the target. The **Celestron SkyProdigy 130** (\$700) costs half as much as comparable products, aligns with minimal input and takes just 3 minutes to home in on a celestial body. —SETH PORGES





*Turns on
nine cents.*



*At the heart of every vehicle we build is a philosophy that takes what we've learned and puts it into what we love. Only one car has a 271-horsepower engine born from Honda's legendary racing heritage. Presenting the one. **The highly responsive Accord V-6. From Honda.***

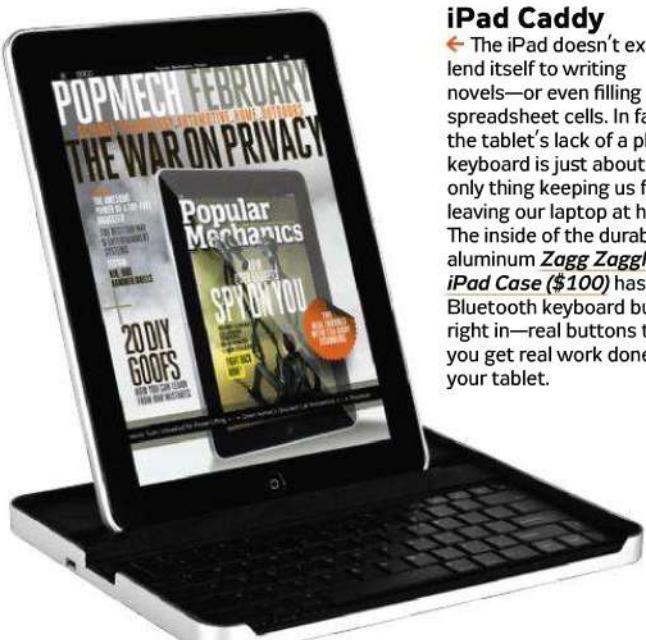


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Accord

**Now See This**

Last year, PM's editors cobbled together a DIY 3D camera out of a metal frame and two Flip-style camcorders. If only we'd had the **Sony MHS-FS3 Bloggie 3D (\$250)**, we could've saved a lot of sweat. The pocket camcorder is one of the tiniest 3D-capable video cams yet, and, like a growing number of handheld devices, its LCD shows footage in 3D without the funny glasses. Nice.

**iPad Caddy**

The iPad doesn't exactly lend itself to writing novels—or even filling spreadsheet cells. In fact, the tablet's lack of a physical keyboard is just about the only thing keeping us from leaving our laptop at home. The inside of the durable aluminum **Zagg ZaggMate iPad Case (\$100)** has a Bluetooth keyboard built right in—real buttons that let you get real work done on your tablet.

Cut. It. Out.

A multihour slog on your average riding mower can feel like sitting on a bar stool bolted to the bed of a pickup truck on a rutted mountain road. Or something like that. Enter the **Cub Cadet Series 2000 Garden Tractor (\$3600-\$7000)**, which takes its cues from a luxury car: power steering, adjustable steering wheel, plush seat with shock absorbers and armrests. Makes a clean, quiet cut too. Sweet ride—but costly.



CIGARETTES

AN HONEST
DAY'S SMOKE.



SURGEON GENERAL'S WARNING: Smoking Causes Lung Cancer, Heart Disease, Emphysema, And May Complicate Pregnancy.

YOUR SPIRIT. YOUR SMOKE.



JOINUSAGOLD.COM

Back to Basics

The **Kodak EasyShare Sport (\$80)** has no built-in Wi-Fi, no automatic face detection, no optical zoom—no anything that's all the rage. It's just a pocket-friendly, reliable, waterproof 12-megapixel camera at a price that won't make you feel too bad if you happen to leave it behind at the beach.



Traffic Cop ↪ GPS traffic information tends to be as reliable as a candle in the wind (with apologies to Sir Elton). The **TomTom GO Live 2500 Series GPS (\$350)** is the first to use the company's new HD Traffic service, which can be counted on like a strontium nitrate road flare. According to TomTom, the device delivers doubly accurate traffic info, 12 times the coverage area and far more frequent updates. So how does it work? TomTom has spent years pulling users' traffic data (anonymously) to gauge traffic movement. That baseline info is updated every 2 minutes, with input from third-party fleets, as well as publicly available accident and construction reports. The result is an omniscient view of traffic on 6 million miles of roads. Sounds impressive—we can't wait to test it.

Blue Blockers

Most 3D-TV glasses rely on IR signals—the same kind that television remotes use—to sync with their sets. But because IR requires an unobstructed sightline to the screen, trips to the kitchen (or even an abrupt head tilt) can throw off the scene-popping spectacles. The **Samsung SSG-3700CR 3D glasses** (*price not set*) eschew IR for the far more forgiving Bluetooth wireless. One downside: They only work with a few Samsung models for now. Let's hope other companies catch on soon.



Gout's root cause is high uric acid. If you have gout, high uric acid can lead to more attacks. To help reduce attacks, lower your uric acid.

ULORIC can help. ULORIC is clinically proven to help lower uric acid to a healthy level (less than 6 mg/dL).

Struggling with gout? Ask your doctor how ULORIC can help lower uric acid and bring gout's root cause down to a more manageable size.

Use of ULORIC

ULORIC is a prescription medicine used to lower blood uric acid levels in adults with gout. ULORIC is not for the treatment of high uric acid without a history of gout. Individual results may vary.

Important Safety Information

- Do not take ULORIC if you are taking Azathioprine, Mercaptopurine, or Theophylline.
- Your gout may flare up when you start taking ULORIC; do not stop taking your ULORIC even if you have a flare. Your healthcare provider may give you other medicines to help prevent your gout flares.
- A small number of heart attacks, strokes, and heart-related deaths were seen in clinical studies. It is not certain that ULORIC caused these events.
- Tell your healthcare professional about liver or kidney problems or a history of heart disease or stroke.

- Your healthcare professional may do blood tests to check your liver function while you are taking ULORIC.
- The most common side effects of ULORIC are liver problems, nausea, gout flares, joint pain, and rash.

Please see accompanying Important Patient Information for ULORIC on adjacent page and talk to your healthcare professional.

You are encouraged to report negative side effects of prescription drugs to the FDA. Visit www.fda.gov/medwatch, or call 1-800-FDA-1088.

For more information, visit www.ULORIC.com or call 1-877-ULORIC-6.



Learn more

Use ScanLife or text GOUT to 299669. You can also download a QR-Code Reader at www.2dscan.com. Message and data rates may apply. May not be available on all devices.



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Uloric
(febuxostat)
40mg/80mg
tablets

PATIENT INFORMATION

ULORIC® (U-'lor-ik) (febuxostat) tablets



Read the Patient Information that comes with ULORIC before you start taking it and each time you get a refill. There may be new information. This information does not take the place of talking with your healthcare provider about your medical condition or your treatment.

WHAT IS ULORIC?

ULORIC is a prescription medicine called a xanthine oxidase (XO) inhibitor, used to lower blood uric acid levels in adults with gout.

It is not known if ULORIC is safe and effective in children under 18 years of age.

WHO SHOULD NOT TAKE ULORIC?

Do not take ULORIC if you:

- take Azathioprine (Azasan®, Imuran®)
- take Mercaptopurine (Purinethol®)
- take Theophylline (Theo-24®, Elixophyllin®, Theochron®, Theolair®, Uniphyl®)

It is not known if ULORIC is safe and effective in children under 18 years of age.

WHAT SHOULD I TELL MY HEALTHCARE PROVIDER BEFORE TAKING ULORIC?

Before taking ULORIC tell your healthcare provider about all of your medical conditions, including if you:

- have liver or kidney problems
- have a history of heart disease or stroke
- are pregnant or plan to become pregnant. It is not known if ULORIC will harm your unborn baby. Talk with your healthcare provider if you are pregnant or plan to become pregnant.
- are breast-feeding or plan to breast-feed. It is not known if ULORIC passes into your breast milk. You and your healthcare provider should decide if you should take ULORIC while breast-feeding.

Tell your healthcare provider about all the medicines you take, including prescription and non-prescription medicines, vitamins, and herbal supplements. ULORIC may affect the way other medicines work, and other medicines may affect how ULORIC works.

Know the medicines you take. Keep a list of them and show it to your healthcare provider and pharmacist when you get a new medicine.

HOW SHOULD I TAKE ULORIC?

- Take ULORIC exactly as your healthcare provider tells you to take it.
- ULORIC can be taken with or without food.
- ULORIC can be taken with antacids.
- Your gout may flare up when you start taking ULORIC, do not stop taking your ULORIC even if you have a flare. Your healthcare provider may give you other medicines to help prevent your gout flares.
- Your healthcare provider may do certain tests while you take ULORIC.

WHAT ARE THE POSSIBLE SIDE EFFECTS OF ULORIC?

Heart problems. A small number of heart attacks, strokes and heart-related deaths were seen in clinical studies. It is not certain that ULORIC caused these events.

The most common side effects of ULORIC include:

- liver problems
- nausea
- gout flares
- joint pain
- rash

Tell your healthcare provider if you have any side effect that bothers you or that does not go away. These are not all of the possible side effects of ULORIC. For more information, ask your healthcare provider or pharmacist.

Call your doctor for medical advice about side effects. You may report side effects to the FDA at 1-800-FDA-1088.

HOW SHOULD I STORE ULORIC?

Store ULORIC between 59°F - 86°F (15°C - 30°C).

Keep ULORIC out of the light.

Keep ULORIC and all medicines out of the reach of children.

GENERAL INFORMATION ABOUT THE SAFE AND EFFECTIVE USE OF ULORIC.

Medicines are sometimes prescribed for purposes other than those listed in a patient information leaflet. Do not use ULORIC for a condition for which it was not prescribed. Do not give ULORIC to other people, even if they have the same symptoms that you have. It may harm them.

This patient information leaflet summarizes the most important information about ULORIC. If you would like more information about ULORIC talk with your healthcare provider. You can ask your healthcare provider or pharmacist for information about ULORIC that is written for health professionals. For more information go to www.uloric.com, or call 1-877-825-3327.

WHAT ARE THE INGREDIENTS IN ULORIC?

Active Ingredient: febuxostat

Inactive ingredients include: lactose monohydrate, micro-crystalline cellulose, hydroxypropyl cellulose, sodium croscarmellose, silicon dioxide, magnesium stearate, and Opadry II, green



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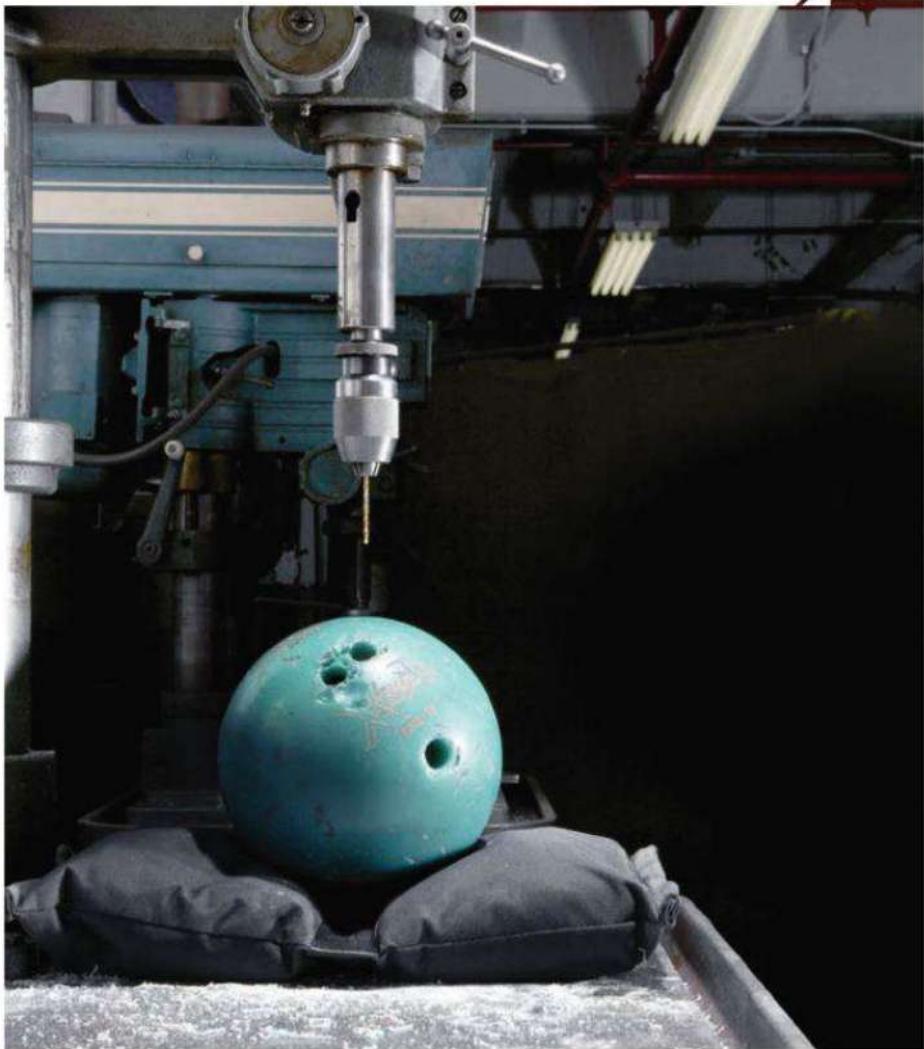
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ABUSIVE LAB TEST

Titanium-Nitride-Coated Drill Bits

Titanium nitride coating turns $\frac{1}{8}$ -inch drill bits into wood-boring, plastic-shredding, metal-cutting dynamos. All brands' bits look the same, but which one bores the best hole? To find out, we used an old bowling ball and a bar of steel to push three bits to the breaking point. **BY HARRY SAWYERS**



BOTTOM LINE

Each bit devoured the resin ball. But against the stainless, the Bosch proved the quickest and most durable: One bore set the test's record time, and a single bit punched a dozen holes. (We all own worn bits—save them for crude drywall or MDF cuts.)

Speed Test

Machinist Mike Conlon at Brooklyn, N.Y.'s Caliper Studio put three bits through an inch-thick bar of 304 stainless steel and into a polyurethane bowling ball. The bit with the fastest average time won.

BOSCH: Bosch bits came through the back side of the bar in 1 minute, 11 seconds on average. The fastest trial was just 32.8 seconds. Burrowing the length of the bit into the ball took 3 seconds.

IRWIN: Conlon averaged 1:44 boring through the steel. The ball holes took 4.5 seconds.

MILWAUKEE: The stainless bar lasted 1:24. Four seconds did the ball in.

WINNER: Bosch.

Durability Test

Conlon sank each bit into the 304 steel repeatedly until the bit broke. He cleared the flutes between holes and lubricated the work with Tap Magic cutting fluid. The winner was the brand that drilled the most holes.

BOSCH: Conlon broke one Bosch on its 12th hole—the record high. Other Bosch bits lasted into their third and fourth attempts.

IRWIN: Irwin's bits usually snapped on the second or third holes. One of them bit the dust, so to speak, on the first hole.

MILWAUKEE: Conlon pushed one Milwaukee into its eighth hole, but killed two on their second holes and a third on its third hole.

WINNER: Bosch.

HOW BITS FAIL

Bent shafts, worn flutes and deformed tips signal dull bits, but the machinists at Caliper Studio seek more subtle clues of failure.

SHAVING: "You want little fingernail shavings, not long curlicues," machinist Josh Sledge says. To extend a bit's life, back it out of the hole to let the flutes eject the cut material, aka swarf.

SHOVING: Dull cutting flutes require more pressure to work.

SCREAMING: Bits change pitch as they dull. Shrieking, chattering or grinding signals a worn edge.

SMOKING: The dullest bits emit a plume of smoke—a sign the front cutting spurs are ground to a nub.

COMING SOON

The March PopMech App



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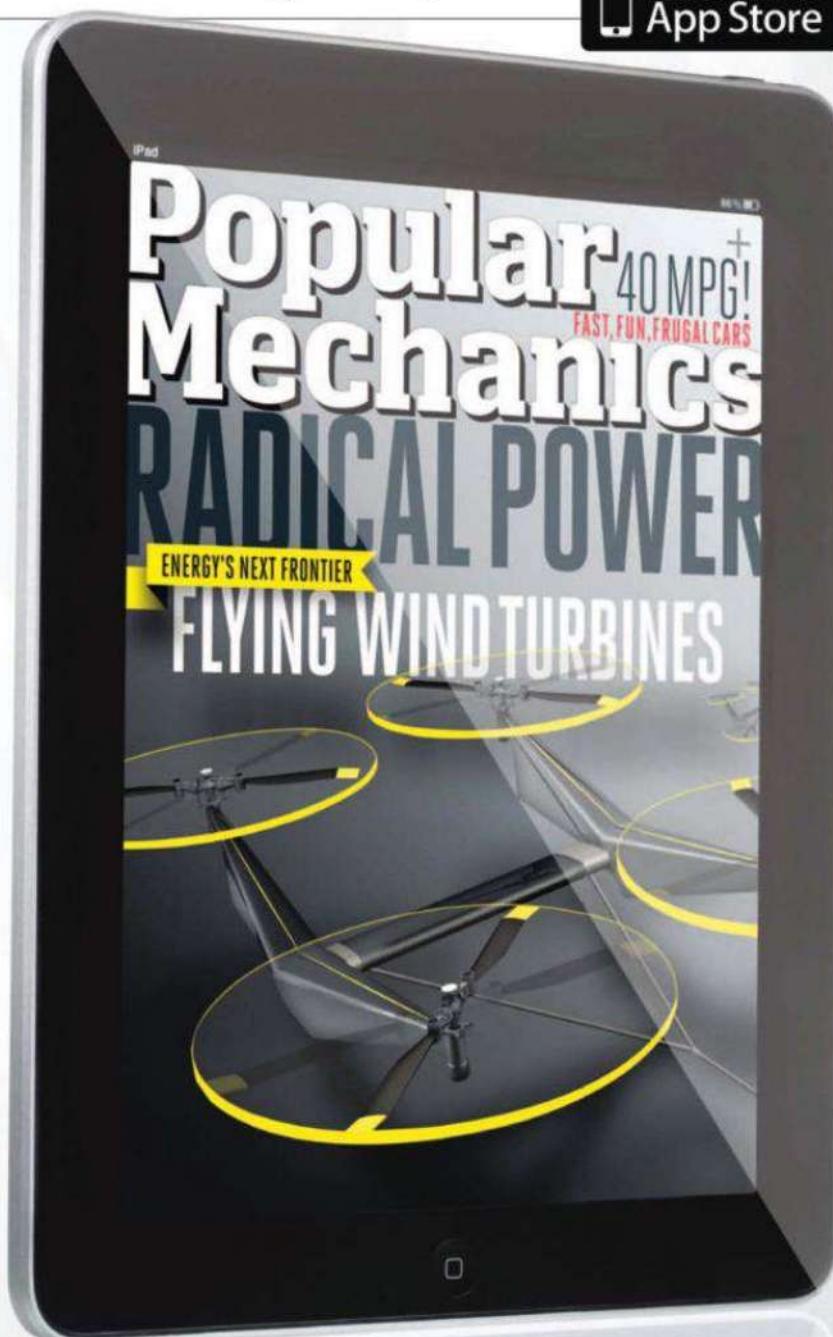
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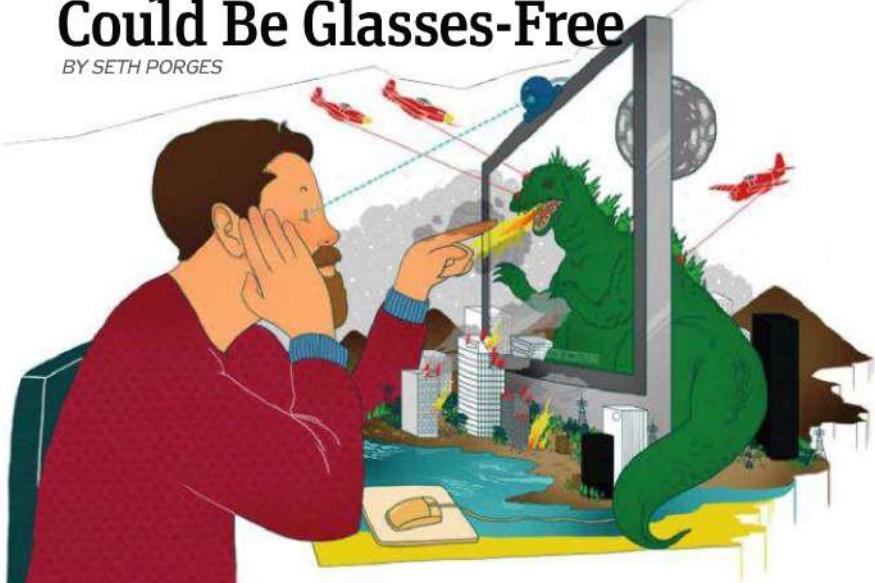
Each month, the Popular Mechanics team takes every word and picture of the print issue, optimizes it for the iPad experience and adds interactive functionality to best enhance the individual stories. The result? PopMech: a must-download app! This month, don't miss our Monster PC and Radical Energy coverage.



↓ ANALYSIS

Why the Future of 3D Could Be Glasses-Free

BY SETH PORGES



TODAY'S WORD IS "AUTOSTEREOSCOPY," or, in plain English, glasses-free 3D. Sure, these sci-fi screens exist today, but because they work by directing particular pixels to particular ocular vantage points, stepping a few inches outside a sweet spot can transform that fourth-wall-breaking Na'vi into a blue blur. This is why the tech is, thus far, found mostly on handheld gadgets such as the Nintendo 3DS—users keep a constant grip on the screen and can control the viewing angle for optimal 3D joy.

But that could soon change. Toshiba recently showed me a technology that I believe could lead the way to larger and more usable autostereoscopic displays. Using a laptop webcam to track a user's eyes, the company built a PC with a 3D screen that can dynamically adjust to provide naked-eye viewing from any angle. The result is a far greater freedom of mobility—and visual clarity—than is provided by current glasses-free 3D screens.

The tech now limits viewing to a single user on a laptop screen, but we can easily see how it could be adapted for large-screen viewing by multiple people. Consider: The cameras embedded in the Microsoft Kinect sensor bar can simultaneously track subtle movements by more than one person. In other words, they collect enough data to possibly allow a glasses-free 3D TV to accommodate multiple people at multiple sweet spots. Of course, neither Microsoft nor Toshiba has made any indication that it is working on this. So, hackers, get busy—the ultimate Super Bowl party is within your grasp.



Dynamic Duo ← The 3 3/8-inch cordless circular saw in **Makita's 12-Volt Two-Piece Lithium-Ion Combo Kit** (\$180) provides a maximum cutting depth of just an inch. Slight, you say. But with sheet goods dominating DIY projects from radiator covers to window boxes, this cutter—paired with a 12-volt driver capable of boring 3/4-inch holes and driving 2 1/2-inch wood screws—is plenty of hardware for any plywood-centric project. Oh, and the retro, turquoise-colored case will gussy up even the dingiest workshop.

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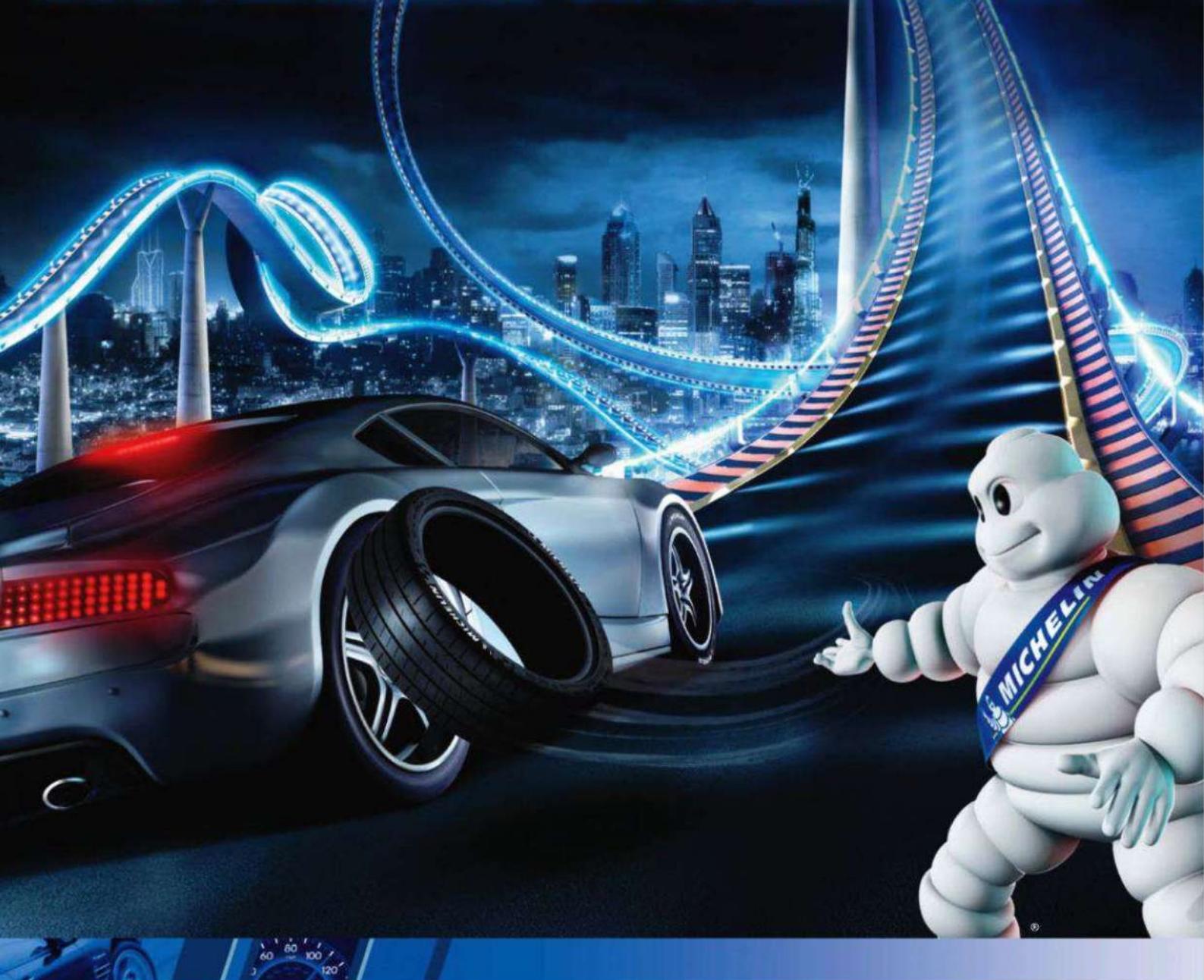


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1- Based upon commissioned 3rd-party testing conducted by TUV Automotive and DEKRA Test Center of MICHELIN® Pilot® Super Sport vs. Bridgestone® Potenza™ RE050A, Continental® ContiSportContact™ 3, Dunlop® SP Sport Maxx® GT, Goodyear® Eagle® F1 Asymmetric, and Pirelli® PZero.™ 2 - Some vehicles come from the vehicle manufacturer with "split fitments" – meaning different size tires on the front vs. the rear. Because these tires cannot be rotated as recommended by Michelin, the mileage warranty on each rear tire will cover half the number of miles as the standard mileage warranty for that particular tire. ©2011 Michelin North America, Inc. All Rights Reserved.



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+ LAMBO V12 + HYBRID RACER



New Cars

2012
**FIAT
500**

BASE PRICE
\$15,500



Italian Renaissance

++ PM TEST-DRIVEN

In the 29 years since Fiat's U.S. retreat (remember the X1/9?), the company has addressed well-known quality issues and partnered with Chrysler, and now it returns with the diminutive and stylish 500. It's an Italian version of the Mini, a modern interpretation of a charismatic vintage model (the original 500 was built from 1957 to 1975), and only a pair of dimples would make it cuter. A four-cylinder engine with Fiat's MultiAir variable valve-lift

mechanism produces 101 hp and powers the front wheels through either a five-speed manual or an optional six-speed auto. On twisty two-lane roads north of New York City, the 500 proved spirited, eagerly zinging through curves. It felt nimble but—thanks to the clever cabin design—not excessively small. The efficient engine and low weight (2500 pounds) help the 500 achieve about 40 mpg on the highway. Cute—and thrifty.

—JOE BARGMANN



THE NEXT STEP ▶ Mercedes-Benz has announced that by 2015, the company's lineup will include a hydrogen-powered fuel-cell car, effectively leapfrogging the current influx of EVs with technology many think is the endgame for automobile propulsion. (This is despite questions regarding the generation of hydrogen fuel, most of which now comes from natural gas.) With EVs barely out of the gate, we were thinking, hydrogen—already? But after driving Benz's latest pilot-program fuel-cell car, the F-Cell, we believe the aggressive production schedule may be on target. The F-Cell is really an electric–hydrogen hybrid: A 136-hp electric motor fed by a small 1.4-kwh lithium-ion battery that picks up the slack for the sometimes sluggish response of the fuel cell. Most of the power components are packaged in the car's floor, saving space. At 2 tons, the car is heavy for its size. But the F-Cell is quiet and refined, and its passage from one place to another is similar to that of a gas-powered car—with the notable exception that it produces only water as a byproduct. At this point, the main thing holding back fuel-cell cars is the scant hydrogen infrastructure. —BARRY WINFIELD

Three in One



With alternative powertrains all the rage (see above), Audi enters the fray with an intriguing prototype. The A1 e-tron is an electrified version of the company's compact A1 (hold the steak-sauce jokes, please), with a 102-hp electric-drive motor and a 15-kwh Li-ion battery pack. That sounds straightforward enough, but the e-tron adds to the formula with a small, range-extending rotary gas engine. Rotaries are rare these days (only the Mazda RX-8 still uses one), mostly because they're thirsty, but the engines

are extremely space-efficient and smooth. The e-tron's 254-cc rotary fits under the cargo floor and spins a 15-kw generator. That alone isn't enough to power the car, but the two energy sources together give the e-tron a range of 155 miles on a fully charged battery, according to Audi. (By comparison, the Nissan Leaf's 24-kwh battery is good for about 100 miles.) Oh, and since the e-tron has the highest fun factor of all the hybrids we've driven, we sincerely hope Audi brings it to market. —BEN WOJDYLA

2012 Ford Focus



FOCUSING ON POLISH

► Finally, we get the good Focus, the one designed and developed in Europe. Clever details punctuate the crisp, contemporary design, including tiny wings molded into the taillamps to smooth airflow, and active shutters that close off the grille opening to reduce drag. A new 160-hp DOHC 2.0-liter engine features direct injection, plus variable timing on both cams. Fuel economy with the five-speed manual is good, at 27/36, but the optional

twin-clutch six-speed auto delivers 28/38. While smooth in traffic, the auto stumbles when pushed on open roads, though the

sharply tuned chassis makes up for the shortfall. Available as a sedan or a hatchback, it starts at \$16,995. —REX ROY

Svelte Wagon



► With enough room for a young family and its stuff, yet more efficient and nimbler than an SUV, the 2011 Acura TSX Sport Wagon aims at Gen X and Y buyers who don't share baby boomers' anti-wagon prejudices. For now, Acura wagons use the 201-hp 170 lb-ft 2.4-liter inline four and a five-speed automatic (the sedan's V6 isn't offered in the U.S. market). The wheelbase matches that of the Acura sedans, but the wagon is 3.6 inches longer overall. To increase rigidity, the tailgate has a "hoop cross-section" structure, which adds to the wagon's weight (132 pounds more than the sedan's)—but the ride is taut. Its 60.5 cubic feet of cargo volume trumps the Audi A4 wagon. Like the 2011 TSX sedans, the wagon features an upgraded exterior and interior, in keeping with its luxurious air, and fuel economy is up 1 mpg to 22 city/31 highway. At \$31,820, the base car is well-equipped, but goodies like a power tailgate and navigation system are optional. —BARRY WINFIELD



2011
Acura TSX
Sport Wagon

NEW EV PLAYER

► Soon, your choices for EVs will go beyond Tesla, Nissan, Chevy and Mitsubishi. Coda Automotive, a new American car company, plans to offer a humble little EV this year with a 90- to 120-mile range. The 3600-pound sedan is based on an older-generation Chinese-market Mitsubishi that has been re-engineered for the U.S. and to

accept a nearly flat 33.8-kwh Li-ion battery pack. The company says that the 700-pound air-cooled battery pack fully charges in just 6 hours using a 220-volt line, or 12 to 15 hours on a 110-volt outlet. The \$44,900 base price drops to \$37,400 with the federal tax credit, but that's still pricier than the Chevy Volt and the Nissan Leaf—which are both

more sophisticated than the Coda. "You are paying for more range, durability and a faster charge," says Sean Blankenship, Coda's marketing VP. Perhaps, but that battery tech is still untested—and wrapped in an ancient Mitsu. Nonetheless, Coda is ambitious, aiming to sell 4000 cars this year and upwards of 14,000 in 2012.

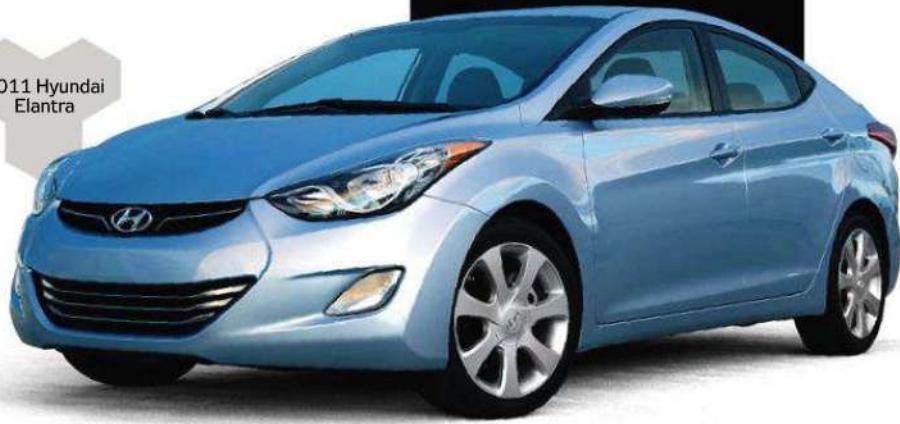
—BEN STEWART

2011
Coda



++ PM FIRST LOOK

2011 Hyundai Elantra



More Car, Better Efficiency

Small, low-price cars are still Hyundai's bread and butter, but the firm's larger sedans influence the design and dynamics of its smaller models. Consider the 2011 Elantra: It's an inch longer than the 2010 version, and the interior volume of 95.6 cubic feet even merits a "midsize" EPA label. The aluminum 1.8-liter engine generates 148 hp and 131 lb-ft of torque, beating the 2010's 2.0-liter iron-block. Bigger and stronger usually means less fuel-efficient, but with six-speed transmissions, reduced rolling resistance and a 62-pound weight cut, the Elantra now claims fuel economy of 29/40. Equipment levels are high, but the starting price (\$15,500) is below other 40-mpg cars. Passengers less than 6 feet tall fit comfortably in the rear seats. Indeed, the Elantra has enough game to challenge more upscale models. — BASEM WASEF

HAS THE JEEP GONE SOFT?

The 2011 Jeep Wrangler's interior adds a touch of luxury to the rugged icon. Flexible and padded materials replace hard plastics, and a new center stack and dash

look more organic. Controls and switches were redesigned but not relocated. Hardtops have better sound-proofing and 25 percent more glass for better visibility. The new Wrangler even offers heated seats,

perfect for chilly, top-down adventures. Still on the JK platform, the 4x4 relies on the aging 3.8-liter V6, rated at 202 hp and 237 lb-ft. In off-road driving over rugged terrain near Jackson Hole, Wyo., the Wrangler proved as

capable as ever, while the ride was quieter and the new switch-gear felt more solid. For 70 years, Jeep has been civilizing a vehicle that began life as a military tool; this is another small step. — MARK WILLIAMS



2011 Jeep Wrangler

The Wrangler's interior materials are more plush but can still be hosed down.



THE V12 LIVES!

While the rest of the world contemplates life without V8 engines, Lamborghini is unveiling its most outrageous power unit yet, a **6.5-liter V12**. While there is some new tech here, like variable cam timing and intake volume, the aluminum V12 relies mostly on short piston strokes (76.4 mm) and high rpm (it wails to 8500) to produce a don't-tell-the-EPA 700 hp. A new seven-speed gearbox will route the power to all four wheels of the next Murciélagos. Wow. — ANDREW ENGLISH

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Tricky Sticker

BY REX ROY

The EPA has redesigned its well-known new-car window sticker to accommodate electrically powered vehicles such as the Chevy Volt and Nissan Leaf. So what's the fuel economy of a car that doesn't burn fuel? Using the Volt's sticker as a guide, we explain the methods behind the numbers.

Electric Efficiency

The boldface 93 mpg is impressive, but there's a caveat—the "equivalent," which is an estimation of the Volt's electric-only efficiency. The EPA runs the Volt on simulated highway and city lab tests and records the miles traveled and the kilowatt-hours consumed. It then converts the kilowatt-hours to gallons of gas (1 gallon of gas contains about 33.7 kWh). A more instructive measure would be the so-called well-to-wheels efficiency of the electricity and gasoline, but since the origin of the two power sources varies (coal, oil, wind, natural gas, hydro, etc.)—and that calculation is so complicated and heavily debated—we're stuck with the simpler measure of the Volt's efficiency.

EPA Fuel Economy and Environmental Comparisons

Charge Time

4 hours @ 240V

All Electric

When battery is fully charged, first 35 miles only.

93 MPG equivalent
36 kWh per 100 miles
combined city/hwy

\$601 cost per year if always run in All Electric

35

Range (Miles)

All Electric Range (battery)

0 10 20 30 40

Extended Range (gas)

50 60 350 360

Dual Fuel Vehicle: Electricity-Gasoline

Gas Only

When electricity is used up, runs on gas for another 344 miles.

37 MPG
2.7 gallons per 100 miles
combined city/hwy

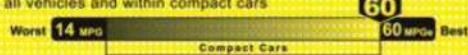
\$1,302 cost per year if always run in Gas Only mode

379



How This Vehicle Compares

(combined composite) Among all vehicles and within compact cars



Greenhouse Gases (CO₂ g/mile, tailpipe only)



Other Air Pollutants



Examples: Charging Routines

Miles driven between full charge	Fuel Economy MPG	Electricity Consumed	Electricity + Fuel Energy Cost
30	N/A	10.9 kWh	4¢/mi
45	168	12.9 kWh	5¢/mi
60	89	12.9 kWh	6¢/mi
75	69	12.9 kWh	7¢/mi
Never Charge	37.35 city / 40 hwy	N/A	9¢/mi

Your actual mileage and costs will vary with fuel cost, temperature, driving conditions, and how you drive and maintain your vehicle. Cost estimates are based on 15,000 miles per year at \$3.20 per gallon and 11 cents per kWh. MPG equivalent: 33.7 kWh = 1 gallon gasoline energy.

Visit www.fueleconomy.gov to download the Fuel Economy Guide (also available at dealers).



60 MPGE?

Now we enter the EPA's back room, where the agency attempts to marry the EV range with gas consumption into one easily digestible figure. That's no easy task, and requires some broad assumptions that won't apply to many drivers. The EPA relied on the 2001 National Household Travel Survey and concluded that most owners will drive the Volt in EV mode 58 percent of the time. This "utility factor" was then used to calculate the combined mpge and tailpipe emissions grades.

EV Range

Based on its tests, the EPA calculates an expected EV range. In our test, we found it to be about 33 miles.

How Far Do You Drive?

Here, in tabular form, is the perfect illustration of why determining the Volt's mileage is so elusive: Short trips between battery charges will ultimately lead to less gas being burned. This quick reference chart also illuminates a major EV advantage—electrons are presently cheaper than gasoline.

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The Hybrid Race Car

Consumers have already welcomed fuel-saving hybrids, but so far auto racers have been slow to follow. A group of Honda engineers aims to create a new class of speedster. **BY LARRY WEBSTER**



▶ **FOR A CAR THAT JUST 8 HOURS** earlier barrel-rolled like it was auditioning for a driver's-ed scare flick—crashed by a member of my racing team—the Honda CR-Z feels remarkably unscathed. "You okay to keep driving after we refuel?" pit boss Mike Kinstle asks via the helmet radio. I hear fatigue in his voice, which is bad, since it's midnight, the race is just halfway over, and the crew has already resurrected a car any insurance adjuster would have deemed totaled.

Kinstle's a Honda engineer and the lead guy behind a pair of gas-electric hybrid CR-Zs modified to race in the 25 Hours of Thunderhill, a mostly amateur version of the 24 Hours of Le Mans that takes place on a 3-mile course north of San Francisco. "We wanted to see if the economy of a hybrid would create a performance edge," he says. "In an endurance race, mileage nearly trumps speed, because pit stops waste time."

Despite that, the racing community has only dabbled in hybrids. Formula One permitted mild hybrids (the KERS system) for only one year, in 2009. Porsche is well-known for its hybrid-racing effort, even though it's limited to one model, a 4WD 911 with a flywheel energy-storage unit. So, the Honda crew is trailblazing with its CR-Zs.

The car's basic hardware remains—a 1.5-liter gas four-cylinder and an electric motor are linked to the six-speed manual gearbox—but it has been maxed out. A turbocharger pushes the engine to 155 hp, and a 7-kwh 173-volt Li-ion pack replaces the standard 100-volt 0.6-kwh nickel-metal-hydride battery. The electric assist provides a 22-hp boost but does not increase the peak power, which the rules limit to 155 hp.

From behind the wheel the extra bump is hard to detect, but that's because my brain is on overload. A steady rain coats the track like WD-40, and the 65 other cars have lighthouse-worthy headlamps that strobe through my cockpit. On the long front straight, the top speed brushes 110 mph, plenty fast for this amateur. "I'll keep driving," I say over the radio, "until you forcibly remove me."

The morning after my 3-hour stint, our car is parked for good, due to a failed transmission. The other CR-Z placed second in its class, but only because of a fuel-spill penalty. More to the point, the CR-Z's average lap time was about 123 seconds—the same as that of the Civics the team ran last year, but the CR-Z got 20 percent better fuel economy. The era of the hybrid race car is just beginning.



The author behind the wheel.



The CR-Z's larger battery pack fits in the spare-tire well. The battery is air-cooled, but the electronics, which perform roughly 5000 calculations each second, require a dedicated liquid-cooling circuit.

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• Mazda2 Touring

FIRST REPORT

The Mazda2 and Ford Fiesta are fraternal twins (the two models share platforms), part of a new generation of fuel-efficient yet refined and appealing small cars. We ordered a Mazda for our long-term fleet, and after driving it for a few weeks, our initial impression is that it's excellent. It's certainly a compact, with a diminutive curb stance, but the rear seats are suitable for two adults or three small children. The interior is almost retro in its simplicity—no auto-dim mirror,

paddle shifters or digital gauges—but there are radio and cruise-control buttons conveniently located on the steering wheel. We were gratified to see a full-size spare, although the spare's rim is steel, not aluminum like the rest of the wheels. The only complaint so far is that the cargo-area lid is onerous to remove when the rear seats are folded. We hope the 2's modest size and engine power will translate into good fuel economy.

—MIKE ALLEN

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the last minute so we grabbed all of them. He sold us an enormous cache of his roundest, whitest, most iridescent cultured 5 1/2-6mm pearls for only pennies on the dollar.

But let me get to the point: his loss is your gain. Many of you may be wondering about your next gift for someone special. In the past, Stauer has made gift giving easier with the absolute lowest prices on fine jewelry and luxury goods. This year, we've really come to the rescue.

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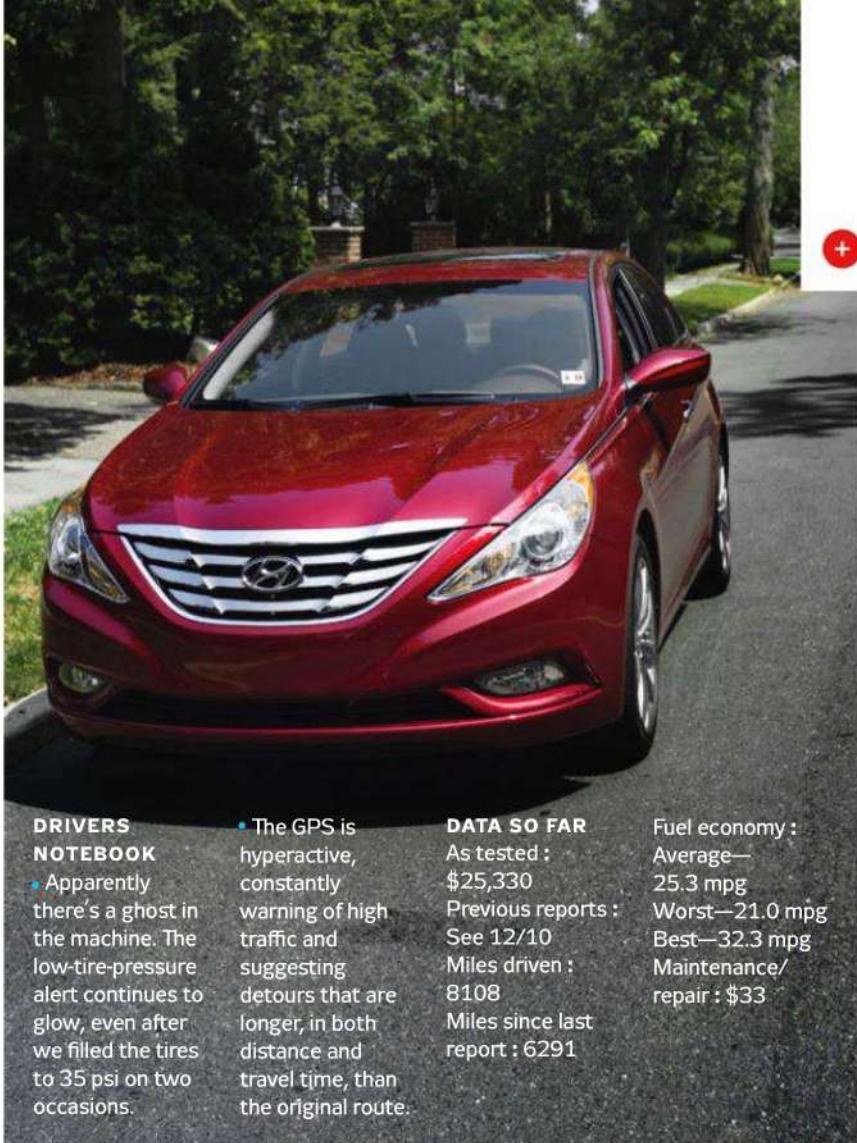
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Hyundai Sonata SE
SECOND report

The Hyundai continues to provide pleasant surprises. We repeatedly hear praise for the Sonata's good looks, and we all give high marks to the roomy interior, capacious trunk (three big suitcases and a set of golf clubs—no problem!), smooth ride and reasonably responsive handling. No staffer raves about the Sonata's wicked torque, Indy-like cornering or muscle-car passing power: The car's not a turtle—the 2.4-liter engine delivers 200 hp, after all—but neither is it a hare. The return for this just-right performance has been good fuel economy, especially on long highway runs. There have been a few complaints: The defroster seems unable to keep the side windows clear in hot, rainy city-driving conditions, and some editors noted poor wet-road traction. But after a 10-day trek from NYC to New Brunswick, Canada, the driver returned with only high praise. Plus, the only service required thus far, at 7500 miles, cost just \$33—so the Sonata's on track to be as inexpensive to own as it is to buy. —JOE BARGMANN

BMW X5 xDrive 35d

The X5's exhaust system uses a urea solution that's injected into the exhaust and reduces nitrous oxide emissions. We were curious to know how long the fluid would last, since the SUV won't run without it. A warning appears on the dash when there's about 1000 miles left in the urea tank, but at 11,800 miles, it wasn't a low-urea warning that sent us to the dealer—it was the first oil-change message. At the service, technicians topped off the 6-gallon urea tank (it took 5 gallons) and replaced the synthetic oil, a lubricant that enables infrequent oil changes. Since all BMWs come with free scheduled maintenance for four years or 50,000 miles, we didn't pay a cent. So far, living with the X5 has been pure pleasure. We've only grown fonder of the diesel engine's combination of low-rpm response and fuel economy—24.1 mpg average—the latter unheard of for an all-wheel-drive SUV that comfortably seats five and has a large 23.2-cubic-foot cargo area. If only more manufacturers offered diesel engines. —LARRY WEBSTER

**DRIVERS
NOTEBOOK**

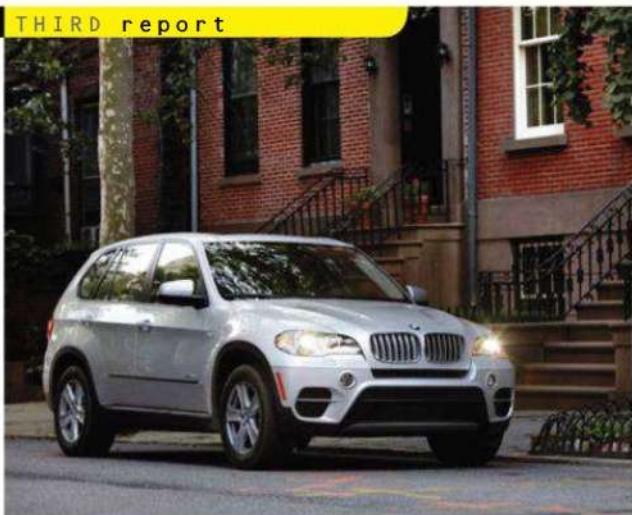
- The X5 can tow 6000 pounds, nearly as much as a pickup, so we

installed a hitch to take advantage of that capability.

- One item has been universally panned: the shifter,

which uses a nonintuitive combination of buttons and lever movements.

THIRD report



DATA SO FAR

As tested :
\$61,025
Previous reports :
See 08/10, 12/10
Miles driven :

12,421

Miles since last report : 4240
Fuel economy :
Average—
24.1 mpg

Worst—18.9 mpg

Best—30.9 mpg
Maintenance/
repair : \$0

DRIVERS
NOTEBOOK
 • With paddle shifters and a seven-speed transmission with rev-matching, the Z turned the mountain roads of Colorado into a playground.
 • The Z's first service was just \$35.50, but the 15,000-mile dealer visit set us back a steep \$647.81.

DATA SO FAR
 As tested : \$44,405
 Previous reports : See 06/10, 08/10, 12/10
 Miles driven : 16,904
 Miles since last report : 4130
 Fuel economy : Average—21.0 mpg
 Worst—9.2 mpg
 Best—28.0 mpg
 Maintenance/repair since last report : \$647.81
 Overall : \$683.31

When the seductive 370Z Roadster first showed up in our fleet, we described it as "the perfect summer fling." With its sensuous design, near-Infiniti-level features (those ventilated seats are almost scandalous) and saucy performance (332 hp), the Z was impossible to resist. There's nothing sensible about a two-seater that barely has room for a couple of gym bags in its trunk. But some cars just make you happy to be alive, and this is one of them. That fling turned into a full-blown love affair. The Z's acid test was a five-day L.A.-to-NYC road trip: If the Z had a dark side, that trip was sure to reveal it. One expects a roadster to be

uncomfortable and noisy. But no, the car was a delight all the way to New York—well-mannered on the interstate, appropriately high-spirited off it. In the end, nothing—not even our urban commute—could dim our ardor. We're trying to get over the end of our Z affair with dignity. But if you happen to catch us late some night, after a couple of beers, please don't ask us about the car that got away. —JIM MEIGS

Nissan 370Z Roadster

FINAL report





At its California headquarters, Joby Energy experiments with radical craft that fly like planes, hover like helicopters and swoop like kites to generate electricity cleanly and efficiently. Here, engineers Allen Ibara (left) and Alex Wickersham help launch the Nymph prototype for Joby's aviation division.

BY JAMES VLAHOS
PHOTOGRAPHS BY JUSTIN FANTL

BLUE SKY POWER

BIG-BUCKS INVESTORS (INCLUDING GOOGLE) ARE GAMBLING TENS OF MILLIONS OF DOLLARS ON A POTENTIALLY GAME-CHANGING NEW ENERGY SOURCE—AIRBORNE WIND TURBINES. THE TECHNOLOGY IS REVOLUTIONARY, BUT CAN IT REALLY TURN A STEADY BREEZE INTO A PAYING PROPOSITION?

TWENTY-FIVE-KNOT GUSTS SWEEP ACROSS THE PACIFIC, SCOOPING UP KITEBOARDERS AND flinging them into the sky. Atop a seaside bluff, the wind races through the grass in long lines, the prairie version of ocean waves, and buffets a panel delivery truck parked at the end of a dirt road. The logo in peeling paint on the side reads TOM'S QUALITY SNACKS . . . FOR EVERY TASTE. But there are no chips or Choco Tacos inside. Instead, four young men sit elbow to elbow, staring at computer screens filled with code. They act like an FBI surveillance team awaiting the big sting, until one of them jumps out the back and grabs what looks like a large model airplane.

He walks downwind, carrying the plane. It's nearly as large as he is. A voice from snack-truck mission control crackles over his radio—"launch when ready"—and he heaves the plane into the sky. The propeller hums. A pilot standing nearby maneuvers the craft with a remote control, but it's obvious this is no hobby flight. Rather than cruising aimlessly, the plane carves identical circles. A tether connects it to the ground—and after a few minutes, the pilot puts his controller down and software takes over. The plane is flying itself.

Of all the things you might guess are taking place, testing a potent new method for generating clean power would probably rank near the bottom of the list. But here on the coast, just north of Santa Cruz, Calif., that's exactly what is happening. These engineers from Joby Energy are developing a technology known as airborne wind. Like traditional wind power, it employs spinning rotors to generate electricity. But the similarity ends there. Joby's engineers want to ditch the bulky support towers of wind farms. They want to teach windmills to fly.

The plane climbed, driven by its propeller, until its tether was taut. But now, the wind alone, racing over the wings, provides sufficient lift, freeing the propeller to function as the rotor of a wind generator. Joby is building models 10 times the size of this research prototype, some with up to 12 rotors. In a fully deployed system, the electricity generated would be routed down the tether and into the grid.

The airborne wind industry is a gnat next to B-52s like hydropower and coal. But the sector is booming, with Joby and its closest rival, Makani Power, leading a race among more than a dozen startups. The companies have poured an estimated \$50 million into R&D, and they are backed by Silicon Valley venture capitalists in search of the next big thing, as well as by ARPA-E, the Department of Energy agency that funds cutting-edge research. The promise of airborne wind has even wowed Google co-founders Larry Page and Sergey Brin, who plunked \$20 million into Makani. Ken Caldeira, a senior climate scientist for the Carnegie Institution for Science at Stanford University, studied airborne wind relative to other energy options and came away impressed. "Airborne wind is one of the few potential sources that can supply power on the scale that civilization needs," he says.

Airborne wind farms might have the same number of turbines, the same distance apart, as today's terrestrial ones. But they would fly on tethers 1000 feet or higher in the sky. Because the wind is stronger and more consistent there, power generation would no longer



be limited to the world's gustiest places, making the technology widely deployable. "Think of an airborne turbine as just a turbine on a really tall tower—without needing to pay for the tower," says JoeBen Bevirt, the founder of Joby Energy.

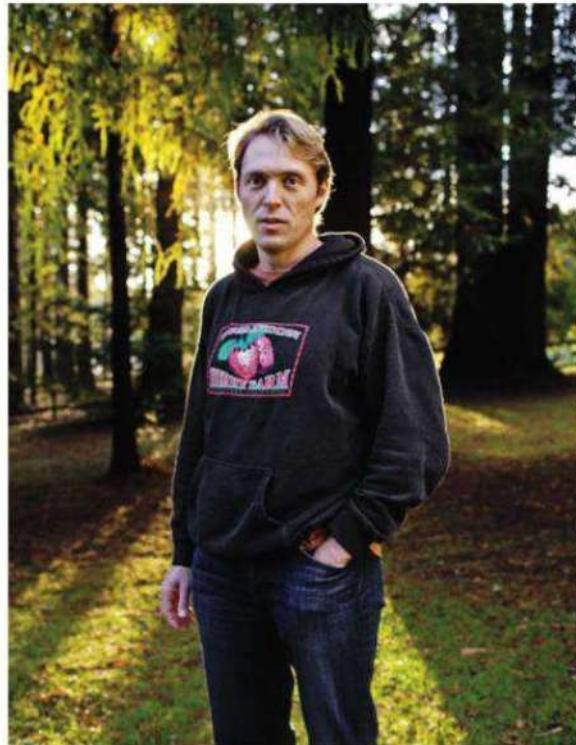
High-yield. Low-cost. Clean. It all sounds great, but for these promises to pan out, the turbines must ultimately be able to take off safely, fly for hours or days and land without a human pilot—critical capabilities that are unproven and years away from commercialization. "The people doing airborne wind are visionaries," says Fort Felker, the National Renewable Energy Laboratory's





Joby engineers develop kite-like generators that ascend on powered rotors, then use the rotors as turbines in looping, tethered flight. Each generator could incorporate up to 12 rotors.

Prototypes dangling from the ceiling at Joby's California offices showcase technological evolution through six iterations. Joby aims to market a 1-megawatt airborne turbine by 2013.



From tripods to turbines: Company founder JoeBen Bevirt helped seed Joby Energy with profits from his GorillaPod line of camera gear.

leading expert on wind power. "But none of them has brought a product to market that has the safety and reliability requirements of flight vehicles."

Inside the snack truck, engineer Henry Hallam tells me, "The plan for the day is to do some endurance testing and autonomous flight. If all goes well, it will be really boring." But the wind is too spirited for boring. On the fourth test, the plane is rocked by a pop; it belches a ball of fire, zigzags and lands hard.

Bevirt vaults from the truck; engineer Greg Horn follows with a fire extinguisher. The plane, fortunately, is fine, and it doesn't take long to figure out what happened. The model is a test-bed for studying flight control systems, not energy production, but the wind was so strong, the motor controller couldn't brake the propeller sufficiently. "We generated so much power, we melted our wires," Horn says. Bevirt turns to me with a smile. "It gives you a sense of how much energy is up there, huh?"

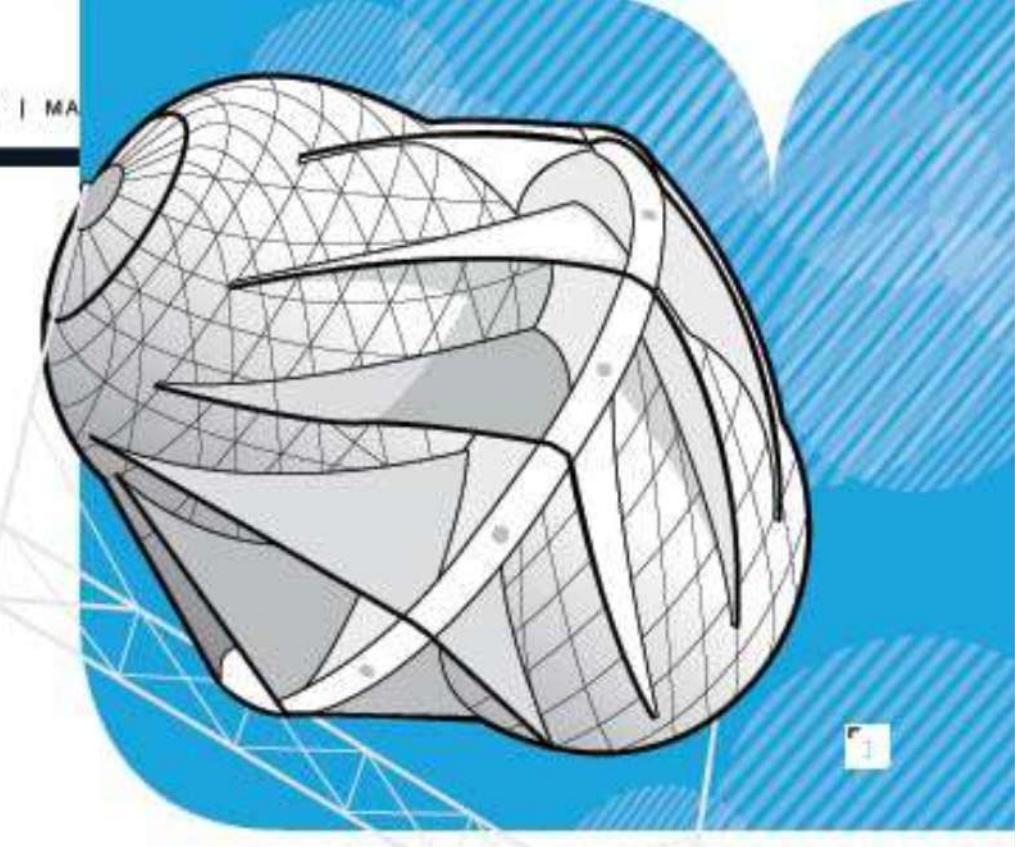
JOBY'S HEADQUARTERS ARE TUCKED into the redwoods of the Santa Cruz Mountains, not far from the test site.

The lodge-like main building is encased by tall windows and trussed with dark wooden beams; outside, there's a deck with barbecues and umbrella-topped tables, a shady lawn and a large organic garden. The place is patrolled by friendly dogs and catered by gourmet chefs, creating a vibe that's less corporate headquarters and more high-end yoga retreat.

Bevirt is pinballing around the grounds when I arrive. He jogs downhill to the warehouse, calling out questions to colleagues and striding between lathes, mills and other shop tools. The 37-year-old has been on the go from an early age: As a high school cycling fanatic, he designed and built several bikes; during college he worked as an engineer and saved \$50,000, which he invested in the stock market.

By the end of the 1990s, after earning a master's degree in mechanical engineering at Stanford University, he cashed out a \$500,000 portfolio and seeded his first business, the laboratory-equipment manufacturer Velocity11, and then Joby, Inc., which makes the GorillaPod line of flexible tripods. These successes gave him the capital to launch Joby Energy, as well as an aviation company. Joby Energy is a project of environmental passion, but it's also a business. "Energy is just a commodity—one electron is no better than another," he says. "What matters is the cost."

Ground-based wind turbines don't spin at full speed every minute of every day. Sometimes the wind blows weakly; sometimes not at all. That's why conventional windmills generate only up to about one-third of their theoretical full power. But the wind where many airborne companies want to fly, at an altitude



tude of about 1300 feet, typically blows more consistently and one and a half to three times faster than at the earth's surface. That means airborne wind could run at a projected capacity factor of 70 percent, Bevirt says—twice the efficiency of terrestrial wind.

Many experts, however, are not yet convinced. The National Renewable Energy Laboratory's Felker says the airborne wind industry probably does have an advantage in capacity factor when its machines are in the air. But land-based turbines can operate roughly 98.5 percent of the time, reliability that flying turbines could not match. "There's no example in the history of the universe of a flight vehicle being available 98.5 percent of the time," Felker says. (Brevirt says that Joby's projections assume airborne turbines will be grounded 5 to 20 percent of the time.)

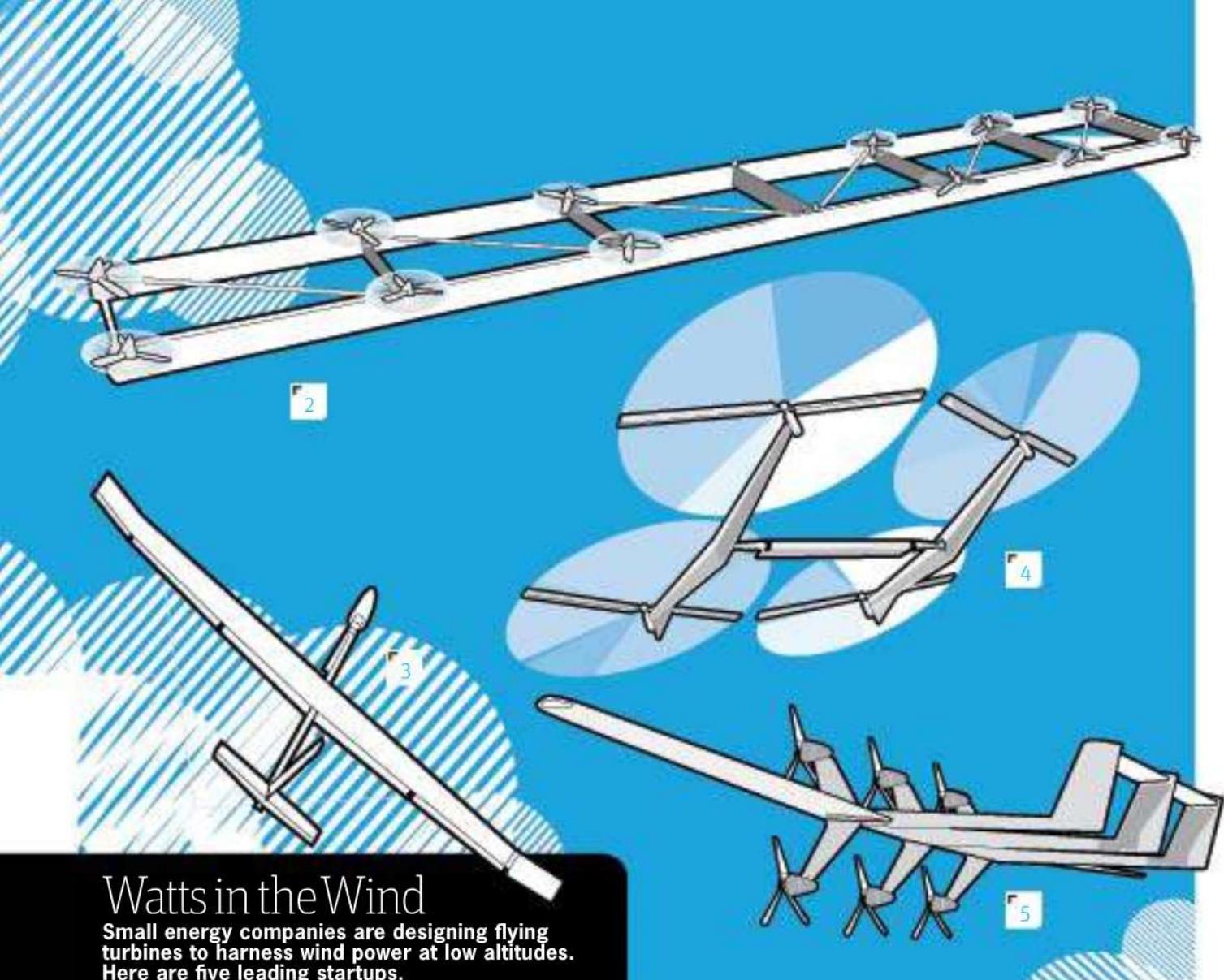
Everyone agrees that airborne wind

needs more R&D. The catch-22 is that proving new technologies takes money, yet investors are wary of the unproven. Furthermore, the industry's path to regulatory approval might be tortuous. Elizabeth Ray, a spokeswoman for the Federal Aviation Administration, said at a recent airborne wind energy conference that flying turbines will have to elbow their way into a sky already crowded with cellphone towers, buildings and aircraft. Airborne turbines, in a perfect world, might one day operate at 30,000 feet to tap the powerful jet stream. Flying at those altitudes would make FAA approval even tougher. "It's all competition for the same finite resource," Ray said—meaning airspace.

Meanwhile, engineers are trying to create flying machines such as the world has never seen—part helicopter, kite, plane and robot. They must be autonomous, because labor costs for ground-based pilots would wipe out the technology's economic advantages. They must be reliable, because life-endangering crashes could scuttle the industry. (For this reason, Bevirt recommends early sites be established in uninhabited areas or offshore.) The public will need to become comfortable with the idea of turbines filling the sky, just as it did a century ago with planes, which are now essentially ignored.

Inside Joby headquarters, a dozen fly-

"THINK OF AN AIRBORNE TURBINE AS JUST A REGULAR TURBINE ON A REALLY TALL TOWER," ONE PROONENT SAYS, "WITHOUT NEEDING TO PAY FOR THE TOWER."



Watts in the Wind

Small energy companies are designing flying turbines to harness wind power at low altitudes. Here are five leading startups.

1 Magenn

The helium-filled Magenn Air Rotor System rotates around a horizontal axis when buffeted by the wind, like a waterwheel on high. Electricity is sent down its tether to the ground, where it can be used immediately, stored in a battery or sent to the power grid. Magenn demonstrated a 10-kw prototype in 2008; a 100-kw version could be on sale by the end of this year.

2 Joby

The 12 turbines on Joby's airborne system have dual functions: providing power for takeoff, then generating it from the wind once aloft. The system flies in large circles perpendicular to the wind direction and covers eight times the swept area of a similarly sized ground turbine. Joby is currently testing 20-kw prototypes and hopes to create a 1-megawatt model by the end of 2013.

Length: 57 ft



Wingspan: 200 ft



3 Ampyx

Ampyx's PowerPlane is designed to fly figure-eight patterns, unreeling a tether at its ground station. The unwinding spins a drum at the station, creating electricity. When the cable is fully extended, the plane dives toward the ground, allowing the cable to be reeled in and the process to be repeated. A 10-kw prototype was flown in 2010; Ampyx hopes a 1-Mw model will be airborne by 2014.

Wingspan: 18 ft

4 Sky WindPower

Sky WindPower's flying generator relies on four spinning rotors to produce energy, sending electricity to the grid through its tether. Power drawn from the ground station helps the craft reach its altitude; the blades then provide enough lift to keep the system hovering. The company flew a 6-kw prototype in 2007 and plans a 1-Mw version by 2014.

Rotors: 35-ft dia



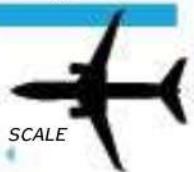
5 Makani

An onboard computer steers Makani's M1 in large circles that cut across the wind. Six small rotors at the center of the aircraft generate electricity that is sent through the anchoring tether and into the power grid. Makani has completed a 10-kw prototype; the company plans to develop a 1-Mw tester by 2013, which could be taken to market two years later.

Wingspan: 115 ft



Boeing 737
Wingspan: 112 ft



ing contraptions dangle from the ceiling, a visual timeline of corporate evolution. There are biplanes, triplanes and what looks like a giant, flying game piece from Trivial Pursuit. Engineer Jeff Gibboney describes a recent Joby design—a 38-foot-long biplane with no fuselage or tail.

"It's like the National Air and Space Museum in here," I say, admiring the collection.

"Yeah," Gibboney replies. "Only weirder."

DAWN BREAKS OVER THE SAN FRANCISCO

Bay. As the soaring bridges fill up with cars, Corwin Hardham paddles his surfboard toward golden clouds. Instead of horns, he hears lapping waves; instead of red taillights, he spots a seal poking its head above the swells. Hardham is the co-founder of Makani Power, and this is his Friday-morning commute. I paddle behind him, precariously balanced on a loaner board.

Once a week Hardham spends rush hour this way because it's greener than driving. Mainly he just loves being out on the water. In his late teens Hardham considered becoming a professional windsurfer, a pursuit that influenced his career in ways no one could have predicted. As an undergrad at MIT, he befriended another technically minded windsurfer, the now-renowned inventor and PM adviser Saul Griffith. After graduate school, they launched Makani Power with a third friend, Don Montague, a former professional windsurfer and kiteboarder. "Wind sports give you a visceral sense of how powerful the wind is," Hardham says.

An hour later, we reach the island of Alameda, where Makani—minus Griffith, who has moved on to other endeavors—has set up shop in the air traffic control building of a decommissioned naval base. We swap wetsuits for work clothes, and Hardham drives us onto the cracked asphalt of the runway, where preflight tests are underway.

Hardham parks by a firetruck that will serve as the anchor for a tether extending 500 feet to Makani's prototype. Wing 6 has a 10-foot-wide airfoil



▲ A time-lapse capture of Makani's airborne turbine shows the crosswind circles it will fly, sending power through a tether to its ground station and then into the grid.

■ A recent Makani prototype, the 10-foot-wide Wing 6, can autonomously hover like a helicopter and fly like a plane in a prescribed pattern.

and a three-pronged body. The tail stabilizer is aligned vertically for the hovering takeoff but will switch to horizontal for flight. "Either mode is relatively straightforward," Hardham says. "The challenge is making a wing that does both."

Altitude aside, the true magic of airborne turbines is that they move. Like a stunt kite on a beach, they zip around in relation to both the ground and the wind direction. This technique, known as crosswind flight, makes it possible to capitalize on net wind speeds that are much higher than the ambient speed alone. The ramifications for the fight against climate change could be huge.

To cap the level of atmospheric CO₂ at roughly double what it was before



Makani Power co-founder Corwin Hardham cleans a lathe at his Alameda, Calif., test facility.

the Industrial Revolution—a common target used by climate scientists—“you’d need something like 15 terawatts of primary power from carbon-neutral sources,” says the Carnegie Institution’s Caldeira. “That’s more or less saying we need to build another energy system as big as the entire current one.” Generating massive amounts of power from traditional solar and wind would require a massive amount of space. “To supply even 20 percent of the electricity in the U.S. from terrestrial wind,” Hardham says, “you would have to cover the state of Kansas with 1.5-megawatt turbines spaced as closely as you could.”

Caldeira and Cristina Archer, an airborne wind expert at California State University, Chico, calculated that airborne wind could be far more efficient. “Airborne wind could potentially produce 18 terawatts of electricity, which is more than enough to power modern civilization without adverse effects on climate,” Caldeira says. Supplying 18 terawatts would require millions of airborne turbines, but Caldeira says his point is not that such a goal is realistic; rather, it’s that large-scale airborne wind production is feasible. He thinks the industry could generate 10 percent of the planet’s power, making it a major contributor to the overall energy mix. A wind farm with 800 airborne 1-megawatt turbines, he says, could power 250,000 homes.

On the runway in Alameda, Makani is working on the transitions between flight modes. No company has completed a fully autonomous flight yet, though both Joby and Makani have prototypes that need pilots only for takeoffs and landings. In the fall of 2010, Wing 6 transitioned from a hovering phase to its flight phase and back to hovering. “That’s an important milestone,” Hardham says. “You can see one craft doing all the necessary flight modes.”

The controllers work through their checklist. “Final wind check,” comes a voice over the radio. “We have 2.4 meters per second. Direction good.” With a whine like angry mosquitoes, and the city of San Francisco twinkling in the background, Wing 6 takes to the sky. **PM**



WE BUILD A SHOP

MIKE ALLEN'S WORKSHOP is an orderly, well-maintained place. Located a few miles from the New Jersey shoreline, the compact garage of PM's senior automotive editor has high shelves stacked with meticulously organized, plainly labeled plastic bins of tools and welding equipment. Occasionally, however, the air in the shop is toxic. Mike is a mechanic and metalworker, and his grinding, routing and drilling sends plumes of metal particulate into the air. This is not so great for the lungs, but positively deadly for electronic equipment.

That's a problem, because a workshop these days needs to be computerized. Mike routinely uses a laptop to run OBD-II diagnostics, search online repair manuals or just blast MP3s of George Thorogood while, say, rebuilding the dry clutch from a Ducati Monster.

But Mike was tired of his laptops burning out every few months. He was looking for a



PC

Palmer Performance Engineering ScanXL USB OBD-II scan tool (\$100)



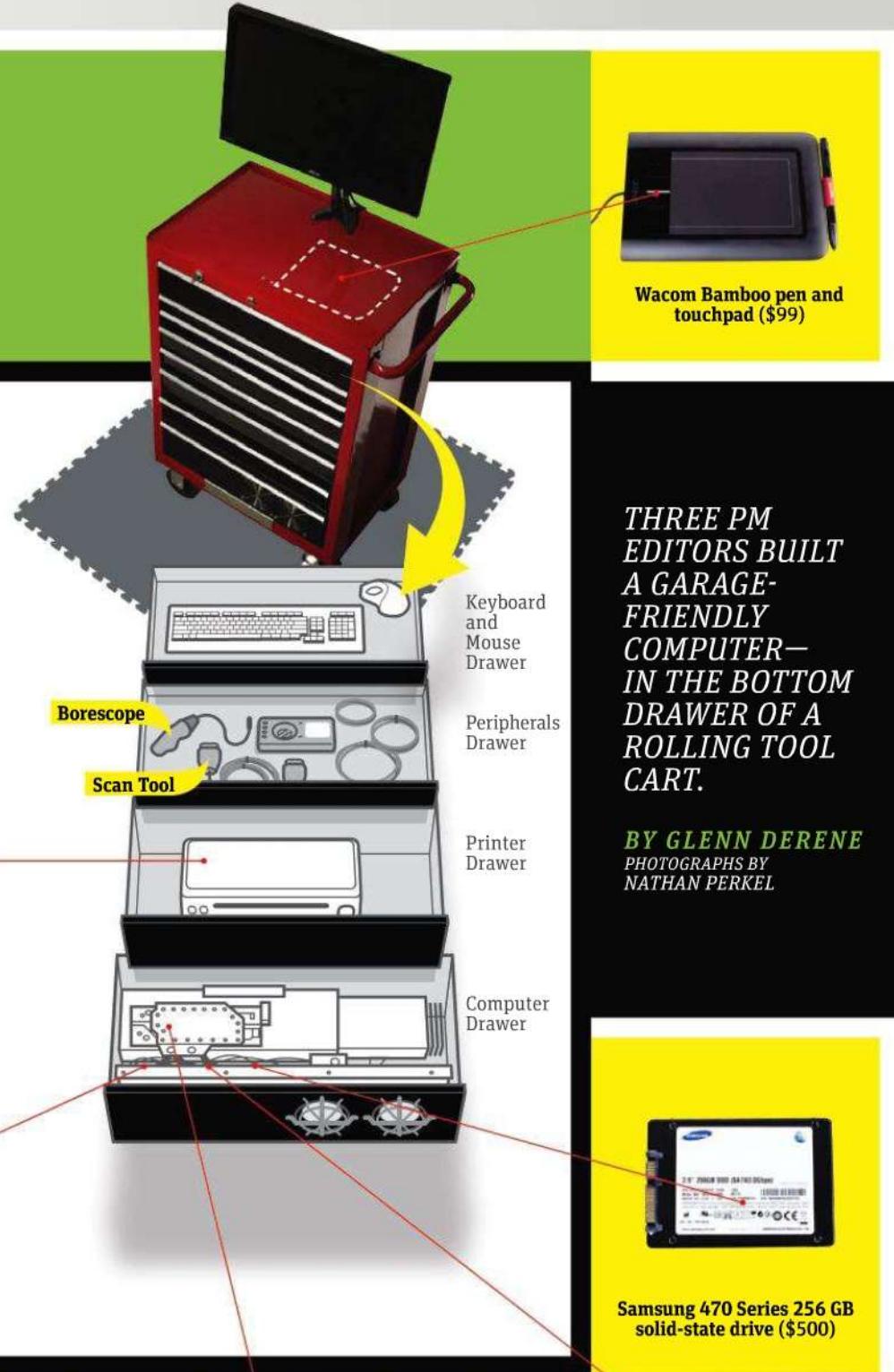
Canon Pixma iP100 printer (\$200)



3 x 2 GB of Kingston Water-Cooled RAM (\$235)



USB borescope (\$62)



ATI Radeon HD 5870 graphics card (\$455) with Koolance water block (\$70)



Asus Crosshair IV Formula motherboard (\$210) and AMD Phenom II X6 1100T processor (\$265)



Samsung 470 Series 256 GB solid-state drive (\$500)



THREE PM EDITORS BUILT A GARAGE-FRIENDLY COMPUTER—IN THE BOTTOM DRAWER OF A ROLLING TOOL CART.

BY GLENN DERENE
PHOTOGRAPHS BY NATHAN PERKEL



*SOME
ASSEMBLY
REQUIRED*

Step 1: Cut to Fit

We took the bottom drawer of a Craftsman tool cart and modified it for PC duty. We needed a few holes for our radiator to make our unique liquid-cooling system work, so we broke out a holesaw.

Step 2: Bend Some Metal

Our segmented design called for a sealed compartment to protect electronic components from metal dust, and a ventilated compartment for airflow to the radiator and fans. This required a steel bulkhead. Mike and his sheet-metal brake obliged.

Step 3: Arrange, Then Rearrange

Unlike a normal PC case, our drawer had no set way to arrange and mount components. We test-fitted our pump, power supply and motherboard to find the most efficient flow for coolant, then used Rivnuts to create mounting points.

Step 4: When You Hit a Wall, Build Up

Normally, graphics cards get mounted directly to a PC motherboard, but our drawer was too shallow. So we mounted our GPU to a custom-fabricated platform, then hooked the card to the mobo using a flexible PCI-E cable. Finally, we rigged up our cooling system (see "Keeping It Cool," opposite).

KEEPING IT COOL

We designed a liquid-cooling system to prevent components (central processor, memory, graphics card and power supply) from overheating inside an airtight case. In our setup, the glycol coolant transfers the heat from the components in the sealed section of the case to a radiator and fans in the open section, which dissipate the heat. All parts and fittings were sourced from Koolance.



Liquid-Cooled Power Supply (\$500): The only one of its kind, this pricey part has two sealed reservoirs.



TNK-400 (\$117): This reservoir and pump combo saves serious space.

Two-Fan Radiator (\$50): The radiator and fans actively cool the liquid glycol.

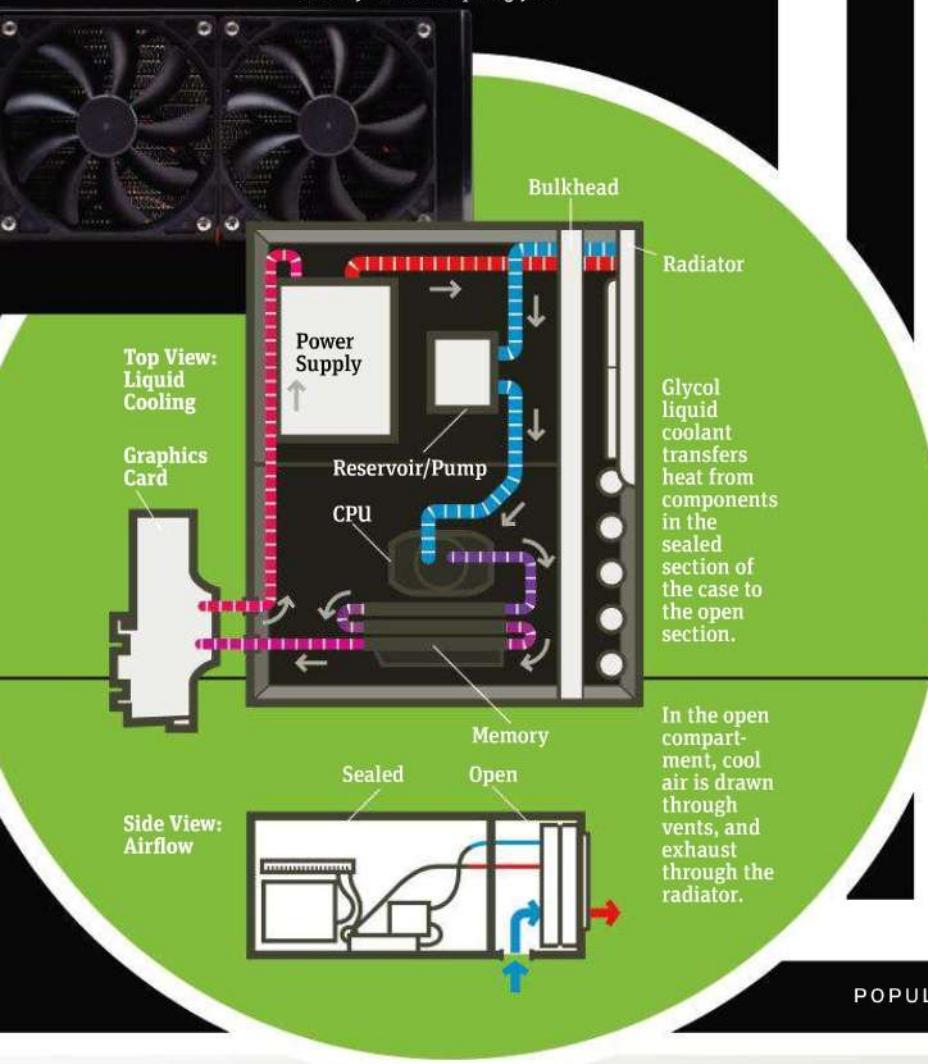
solution that would bring serious computing power into his shop full time—without exposing delicate PC innards to harsh substances. At PM, we love a challenge. Mike and I sat down with PM's master computer builder, Anthony Verducci, to design and construct a machine that could stand up to this unforgiving environment. It turned out to be an interesting exercise in thermal management. We knew that a standard, air-cooled rig with filters on its fans could block some of the particulate, but the only way to truly protect the computer's interior bits would be to seal it off completely from the outside world.

It's one challenge to keep the computer cool—it's quite another to make it *look* cool, so I proposed that we build the machine into a Craftsman rolling tool cart. Mike shaped up a sheet-steel bulkhead that partitioned two-thirds of the bottom drawer into a sealed compartment, then drilled 10 holes in the bottom of the other third to allow for airflow.

Then we plumbed up a liquid-cooling system for all of our critical components: a crushingly powerful six-core, 3.3-GHz AMD Phenom II X6 1100T processor; an ATI Radeon HD 5870 graphics card; 6 GB of high-speed Kingston RAM; and a dual-reservoir Koolance 1000-watt power supply—the only one of its kind. In the open airflow compartment we mounted the radiator and fans to blow the PC's heat to the outside world.

Mike is fastidious about wiring, so he spent a couple of late nights at the garage harnessing and gasketizing all of the USB, SATA, HDMI and power cables exiting our drawer, then routing them through the case. After three days of building, Anthony flipped the switch and our rig booted up, signalling that our work was done.

The shop PC was a difficult beast to build, but we think the concept has legs. After all, the PC is now a universal tool, and Mike's shop isn't the only place where the air gets unfriendly. **PM**



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DOWN IN THE HOLE

THEIR LAUNCH INFRASTRUCTURE IS AGING, AND THE NEW START TREATY CUTS THEIR NUMBERS, BUT AMERICA'S ICBMS REMAIN THE CORNERSTONE OF NUCLEAR DETERRENCE. AND EVERY DAY, AIRMEN DESCEND INTO HARDENED BUNKERS TO AWAIT THE UNTHINKABLE.

BY JOE PAPPALARDO

THE RANCH HOUSE SITTING 50 FEET OFF a two-lane, pothole-riddled road southeast of Great Falls, Mont., is not much to look at. It's a simple one-story structure, surrounded by a chain-link fence, with a detached garage and a basketball hoop in the driveway.

But a closer examination reveals curious details: a red-and-white microwave tower looming over the buildings, a helicopter landing pad in the front yard and a conical ultrahigh-frequency antenna growing from the lawn like a white mushroom. This place could be a university

PHOTOGRAPHS BY JONATHAN TORGOVNIK

Just another workday: Nuclear missile launch teams tether cases containing classified documents to their bodies before heading off to their 24-hour-alert shift in a Montana missile field. If called on, these 20-something Air Force officers will fire their doomsday weapons.

A

agricultural research outpost or a state weather station—except for the red sign on the fence warning that anyone trying to sneak onto the property could be met with lethal force.

A security officer inside the house vets everyone who enters. Any deviation from what is expected—even a misspelled name or a missing middle initial—can bring guards with M4 rifles and handcuffs. The thick front gate opens vertically to avoid being blocked by snow in winter.

Inside, the house becomes a military barracks. A central room is shared living space—television, sofas, love seat and a handful of long tables for group meals. A hallway branches into rooms with bunk beds. Government posters on the walls warn of loose lips and lurking spies.

A bulletproof door in the living area leads to a small side room. There, the flight security controller (FSC), a noncommissioned officer responsible for safeguarding this facility, sits next to a 10-foot-tall locker housing the M4s and M9 handguns. There's yet another door in this security room, one that the FSC and guards never enter except in the case of an extreme emergency. It leads to an elevator that has one stop, six stories below ground.

The FSC speaks softly on the phone, exchanging codes required to make the elevator appear. It won't come up until riders clear and close the security-room door. The elevator's steel door is hand-operated, unrolling like a storefront security shutter to reveal a small box with metal walls.

It takes less than a minute to make the 65-foot descent, but it's a different world down in the hole. The elevator opens to the smooth curve of a black, pill-shaped capsule, interrupted by the thick stubs of pneumatic shock absorbers that can protect occupants from shock waves caused by the nearby blast of a nuclear warhead.

A series of clangs, reminiscent of the sound of a castle's portcullis rising, echo outside the capsule, and moments later a massive hatch slowly swings open, 26-year-old Air Force Capt. Chad Dieterle clinging to its metal handle. The word INDIA is stenciled on the blast door's 4.5-foot-thick inner edge. Dieterle is halfway through his 24-hour shift as commander of Launch Control Center India, built here at Malmstrom Air Force Base when the airman's parents were teens.

LCC India is hard-wired to 50 surrounding silos, each about 7 miles away. Each silo houses a 60-foot-tall Minuteman III Intercontinental Ballistic Missile (ICBM). The Air Force won't confirm the number of warheads in the missiles, but each can hold a maximum of three; every warhead can immolate 65 square miles within minutes of detonation.

A half-hour after receiving the order, Dieterle and his deputy can deliver these weapons anywhere on the globe.

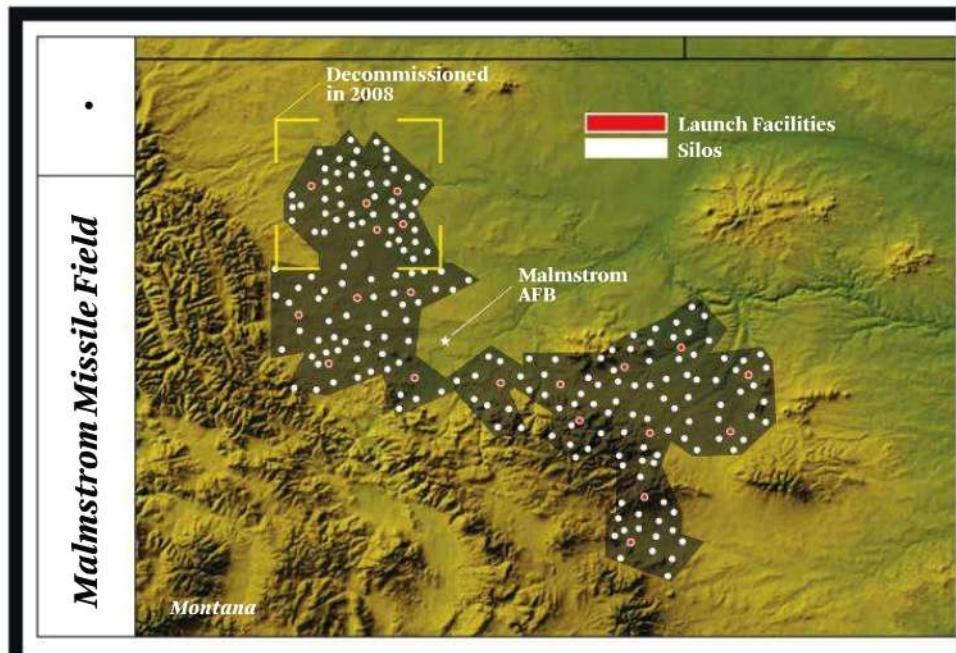
Their quiet, subterranean presence makes this banal Montana ranch house one of the most strategically important locations on the planet.

MERICA'S NUCLEAR ARSENAL—about 2200 strategic warheads carried by 94 bombers, 14 submarines and 450 ICBMs—remains a cornerstone of national security. Despite President Barack Obama's oft-repeated desire to work toward a world without nuclear weapons, his administration's Nuclear Posture Review states that "as long as nuclear weapons exist, the U.S. will maintain safe, secure and effective nuclear forces."

Since the end of the Cold War, the number of nukes worldwide has plummeted, but more nations, including potential foes such as China, Iran and North Korea, have nuclear weapons programs and field long-distance missiles. So America's nuclear stockpile—and the airplanes, submarines and missiles that deliver them—will remain on alert despite any good intentions or lofty rhetoric.

Although the ICBM leg of the U.S. nuclear triad is 50 years old, it remains the focus of intense debate in Washington, D.C., and Moscow. Last year the Obama administration signed the New START treaty with Russia, which would reduce the two countries' nuclear arsenals to fewer than 1550

PHOTOGRAPH BY GETTY IMAGES (SATELLITE MAP); DIAGRAMS BY DOGO





Self-described “missile monkeys” train in a mocked-up Minuteman III silo, rewiring the missile’s rounded gyroscope and boxy radiation-shielded computers. The equipment steers the upper stage before it releases the warheads.



Malmstrom Air Force Base is responsible for 15 nuclear launch facilities and 150 silos spread over 13,800 square miles. The Air Force buried the launch control rooms to thwart a Soviet nuclear onslaught and distributed underground silos so inbound warheads would have to hit each site directly, at ground level, to prevent U.S. retaliation.

strategic warheads within seven years. America’s 450 deployed ICBMs would shrink by 30. To win support from hawkish, skeptical senators, the White House proposed to increase nuclear weapon modernization spending by \$85 billion over the next 10 years. (Future Congresses will have to sign off on those funds.) “I will vote to ratify New START . . . because the president has committed [to] a plan to make sure that those weapons work,” Sen. Lamar Alexander, R-Tenn., said.

WHY ARE ICBMs, icons of the Cold War, still a centerpiece of 21st-century defense, politics and diplomacy? Of the three kinds of delivery systems (aircraft, submarines and missiles), ICBMs promise the fastest response to an enemy’s nuclear attack—or can launch quickly enough to prevent one. Submarines are virtually undetectable and nuclear bombers can strike with precision, but only intercontinental missiles are always ready to deliver a nuke, undeterred, anywhere in the world within minutes. (Submarines have long-range ballistic missiles, but land-based communication is more reliable.) The American ICBM umbrella spans the globe, lowering the number of nukes worldwide by taking the burden of deterrence from allied governments.

“As airmen, we strongly believe that it is important for the United States to be able to hold at risk any adversary’s target, regardless of where it is, regardless of how heavily defended it is, regardless of how deeply buried it may be, regardless of how widely dispersed it may be,” says Lt. Gen. Frank Klotz, who stepped down in January as the head of Global Strike Command, which has stewardship over the nation’s nuclear bombers and missiles.

ICBM fields, unnerving though their purpose may be, are engineering triumphs. The proof is their age—the Air Force installed these launch systems in the early 1960s, and they have stayed at readiness levels exceeding 99 percent ever since. Even more astounding, the Pentagon built the ICBM fields to last only a few decades. When the Minuteman III retires, the silos and launch facilities at Malmstrom will have been buried for 70 years.

Missile Alert Facility

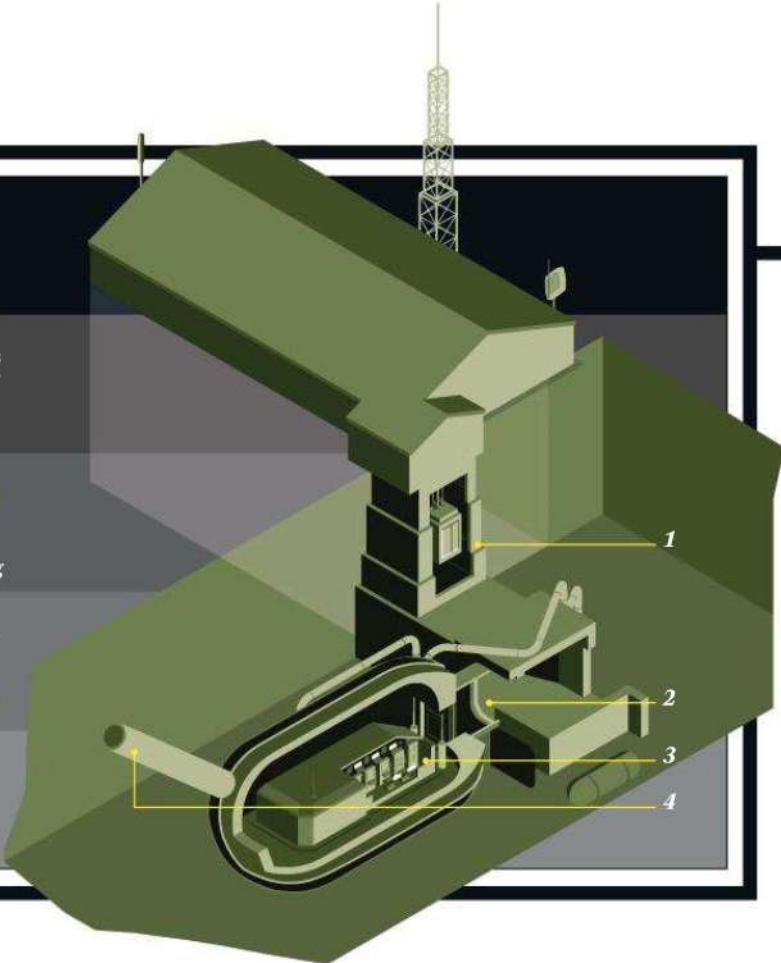
A Missile Alert Facility houses the guards who protect the nearby silos and the Launch Control Center 65 feet below ground. The MAF is staffed 24 hours, every day.

1. Elevator Shaft: Only missileers—and their meals, prepared above—take the trip down.

2. Blast Door: This 4.5-foot-thick door can withstand a nearby nuclear blast. It's hand-operated.

3. Launch Control Center: Two airmen pull 24-hour shifts here, waiting for the Emergency Action Message that would start an ICBM launch.

4. Escape Tunnel: If the elevator is destroyed in a nuclear exchange, the missileers can dig out via this sand-filled tube.



The Air Force monitors the world's most powerful weapons with equipment made during the Space Age, not the Information Age. But these old launch systems are holding up better than most people think. "To build something that has withstood the test of time and continues to be a marvelous engineering system is just nothing short of genius," Klotz says. "The 1960s designers really did think this through very carefully and designed in a lot of redundancy."

It takes thousands of dedicated airmen at three Air Force bases—Malmstrom, F.E. Warren in Wyoming and Minot in North Dakota—to keep the nation's ICBM silos operational. Since 2000, the Pentagon has spent more than \$7 billion on ICBM renovations. None of the money went to launch facilities; the Air Force instead amped up base security, improved command and control cryptography, updated missile guidance systems and replaced rocket fuel. (The same warheads, deployed in 1979, sit in the ICBMs' noses, but this February the National Nuclear Security Administration began studying a replacement, to be produced in 2021.) Klotz says the Air Force has upgraded "every inch" of the Minuteman III missile since replacing its predecessors in the 1970s.

This work was intended to keep the Minuteman IIIs functional until a scheduled retirement in 2020, but last year the Obama administration extended their service lives by another decade. In response, the Air Force is crafting a schedule for improving the missile fields, using some of the billions recently promised by the White House. "As expensive as this sounds, you are building an insurance policy for something where failure is unimaginable," says Anthony Cordesman, an analyst with the Center for Strategic and International Studies, a Washington, D.C., think tank. "The cost of upgrading a distributed ICBM field is fairly minor."

He compares the cost of the Minuteman IIIs to the price of building and maintaining new Ohio-class submarines. The Navy intends to buy 12 new nuclear-armed submarines in 2019. According to the Congressional Budget Office, the sub replacement program alone will run to \$99 billion, with another \$15 billion in research and development. Compared with subs, ICBMs promise Armageddon on a budget.

WITHIN LCC INDIA, beneath the ranch house, Dieterle is working a hand pump that seals the capsule. It's hard to put aside the feeling of being entombed when the reedy sound of air seeping from the edge of the blast door stops.

Very little has changed inside the LCC since the Kennedy administration: Digital screens have replaced paper teletype machines, and servers in the ranch house above provide the capsule crews Internet access as well as Direct TV for slow shifts. But the LCC's oversize electronics, mounted on wide metal racks and studded with raised lights and illuminated buttons, look like something from the set of the original *Star Trek* TV show. Some equipment is painfully old: Dieterle grins sheepishly as he pulls a 9-inch floppy disk from a console, part of the antiquated but functional Strategic Automated Command and Control System.

Unlike missiles and surface-level facilities, the underground silos and LCCs are hard to upgrade and impossible to replace. And they take a beating. Corrosion and rust are insidious foes, and soil shifts can break subterranean communication lines.

Launch Control Center India is one



Senior airman Cory Carlson, a missile maintenance technician, sits beside the forward shroud of a Minuteman III. Once in space, a rocket in the cone jettisons the shroud away from the emerging nuclear warhead.

of 15 LCCs controlled by the missileers of Malmstrom Air Force Base. "Take a 40-year-old home," says Col. Jeff Frankhouser, Malmstrom's maintenance group commander. "Now bury it in the ground. Then figure out what your challenges are. We'll have those."

The base is responsible for 150 nuclear ICBMs scattered across a staggering 13,800 square miles of Montana plains, hills and mountains. The wide distribution made it impossible for the Soviet Union to knock out every silo and LCC with a massive nuclear barrage, which guaranteed that the U.S. could retaliate.

The elegant doctrine of deterrence bred some necessarily unwieldy infrastructure. For example, hundreds of thousands of miles of subterranean communication lines connect LCCs and silos. Each fist-thick cable contains hundreds of insulated copper lines surrounded by a pressurized sheath; the launch and base crews can detect any break or tampering by a drop in pressure.

Personnel at Malmstrom struggle constantly against this dispersed layout. Every day, hundreds of people—30 launch control teams, 135 maintenance workers and 206 security team members—deploy to tend the missile field. Some LCCs, staffed by a proudly suffering squadron called the Farsiders, are a 3-hour drive from the base. SUVs, big rigs and massive missile erectors daily travel more than 25,000 miles of roads, more than 4000 miles of which are gravel.

The motto here is "perfection is the standard," and an army of evaluators hold personnel to this inflexible creed. Any mistakes can lead to an immediate removal from duty until the training staff retests the violator. This level of scrutiny extends to the entire base—officers reprimand cooks for keeping salad dressing beyond its expiration date or failing to clean the hoods over the stoves. Food poisoning can shut down a missile alert facility as neatly as a Russian Spetsnaz special ops team. Being careful to the point of paranoia is a baseline philosophy at Malmstrom. "It

Being careful to the point of paranoia is a baseline philosophy at Malmstrom. "It might seem like overkill," says Col. Mohammed Khan, the 341st Missile Wing's former operations commander. "But hey, these are nukes."



The Air Force built silos (above) on small plots purchased from landowners—a visitor can linger outside the fence and be guilty only of trespassing on private property. But cross the fence and security teams can shoot to kill. Right: A missileer activates a launch at a high-fidelity training simulator.

ICBM Silo

ICBM missile silos hide their lethality in plain sight—a truck driver could pass one just off the interstate and not look twice. But the 90-foot-deep silos house nuclear weapons that must be kept at a constant state of readiness.

1. **UHF Radio Receiver:** This blast-hardened, ultrahigh-frequency antenna can receive a launch order from an aircraft in case the LCC is destroyed or otherwise unable to communicate via landline.
2. **Silo Cap:** A massive piston can fling the 110-ton lid across metal tracks and through the fence. The extra force ensures wreckage cannot stop the silo from opening.
3. **Intrusion Detection Pole:** Doppler radar at the tip bathes the area; intruders captured in the return signal bring armed guards.
4. **Hatch and Ladder:** Air Force personnel access the silo through this highly secured door and a telescoping ladder.
5. **Missile Suspension:** The ICBM is held aloft to protect it from the shock waves of enemy nukes and the exhaust of its four rocket engines.



might seem like overkill," says Col. Mohammed Khan, who served as the 341st Missile Wing's operations commander at Malmstrom until late 2010. "But hey, these are nukes."

Any problem at the silos is a national security event. At 1:40 am on Oct. 23, 2010, the two-man crew of an LCC at F.E. Warren Air Force Base was shocked to see the acronym LFDN, or Launch Facility Down, appearing on the screens that show each silo's status—they had lost contact with the 10 ICBMs under their direct control. Sporadic communication problems also spread to the squadron's four other LCCs.

Warren's airmen and technicians took the afflicted LCC offline, clearing up the communications interference and enabling the rest of the squadron to stay operational. It took days to find the cause: a loose computer data card in the LCC's weapons system processor. The launch center was calling the silos, but it couldn't hear the replies.

The incident never hampered the nation's overall readiness, since the work of one LCC is easily taken up by others at the base. When a communications problem at an ICBM base is serious, an E-6B aircraft takes off from Offutt Air Force Base in Omaha, Neb.,

to serve as an airborne launch control center. That didn't happen on Oct. 23, according to Air Force officials.

Nevertheless, the outage became a rallying cry in Congress to revitalize Minuteman III facilities. "Modernization of our nuclear force is a necessity. The incident at Warren proves this beyond a doubt," Sen. John Barrasso, R-Wyo., wrote in an op-ed. That conclusion ignores the fact that the loss of communications was caused by an upgrade—base maintainers had replaced the data card the day before, but they did not properly seat it, and equipment vibrations shook the card loose.

Modernization has downsides. Upgrades require invasive procedures at the carefully kept facilities; mixing new and old technology can lead to unforeseen problems; and Global Strike Command is struggling with a personnel shortage. "I think we absolutely have to do modernization," says Klotz, who is retiring in March. "But maintaining an aging system, coupled with the efforts to modernize it, places a pretty high workload on all of our bases." Besides, sometimes the old systems are just built tougher. "Systems that are older tend to be more robust and less vulnerable," Klotz says. "There is a certain ruggedness in the design that we might not have if it were relying upon the most up-to-date technology."

NUCLEAR MISSILE LAUNCHES are not activated by the turn of a key. If the call comes to India's LCC, Dieterle and his deputy commander, Capt. Ted Givler, will match the codes from the White House that enable the silos to fire with ones kept in the LCC's metal safes. The pair of missileers would each grip two triangular switches, eyes fixed to a red digital clock ticking away between the consoles. At the predetermined time, they'd turn the triangle from SET to LAUNCH. A second pair of airmen in another LCC would simultaneously turn their switches, and the ICBMs would be free.

Each ICBM tube is good for only one shot—the electronics, ladders, communications wiring, security sensors and sump pump would burn or melt. The Minuteman III would push an obscenely perfect smoke ring shaped like the silo's entrance over the Montana landscape. Billowing exhaust, the missile would reach space in minutes; in a half-hour the warheads would be falling on their targets.

The power of the weapons under the missileers' command and the pressure to be perfect are magnified by the LCC's intense, isolated surroundings. A simple mattress ringed by a blackout curtain is mounted at the far end of the capsule. "This is never a good place to wake up," Dieterle says.

It's time to go up the elevator, back to what the missileers call the real world. With a slow pull, Dieterle tugs the handle of the black blast door until the thick slab starts to turn. He offers one last, slight smile and the door shuts with a thud. Dieterle, or someone like him, is down there now, waiting.

CUTTING CLASS

A COLLEGE CANOE CLUB'S CABIN BURNED TO THE GROUND. BUT STUDENTS RESURRECTED THE LOG CLASSIC USING TRADITIONAL METHODS—WITH A FEW MODERN TWISTS.

ON A FOGGY SPRING MORNING IN 2009, Dartmouth College junior Greg Sokol and a few friends got up before classes and paddled canoes down the Connecticut River in New Hampshire to check on a log cabin not far from campus. It was owned by the school's Ledyard Canoe Club, of which Sokol was a member. Recent rain had swollen the river, and the current was running fast. Sokol led, angling his canoe away from the mouth of Mink Brook and into a tiny cove along Gilman Island's steep northeast shore. He picked his way up the bank and glimpsed the cabin's chimney—too much chimney, actually. Sokol scrambled to the top. In front of him lay the charred remains of Titcomb Cabin. Police would later determine that a fire the night before had probably been set by high school partyers, then blazed out of control.

Like nearly 60 years' worth of students before him, Sokol knew Titcomb well. At Dartmouth, an outdoor spirit is practically grafted onto collegians' DNA. Students maintain cabins and trails throughout the southern White Mountains. This cabin, named for Jack Titcomb, a Dartmouth alumnus who had died fighting in World War II, was Sokol's outdoor base camp. He had forged friendships around its fireplace, slept on its porch and swum in its shadow beneath the moon. Now it was gone.

Oh, well. Sokol was an engineering

BY JIM COLLINS

PHOTOGRAPH
BY BOBBY FISHER



Engineering student Greg Sokol spent his summer building a cabin. Lesson No. 1: Become an artist with a chain saw.

student. He'd never really constructed anything, but he knew his way around a CAD program. And he had a bunch of smart friends. By the time Sokol had paddled back to campus, he'd made up his mind: The cabin would be rebuilt, and he would spearhead the effort.

JUST OVER A YEAR LATER, SOKOL AND a small team of fellow students assembled in a field 3 miles upriver from the building site. Some 97 red-pine and spruce logs (which had been selected and felled at a Dartmouth woodlot) had already been delivered and lay baking under the July sun. The crew planned to spend several days practicing the ancient art of scribing, notching and fitting logs. But first they needed to brush up their skills in using a crucial tool: One by one, they fired up their chain saws.

It hadn't been difficult to gather volunteers. A few months earlier, a campus-wide e-mail titled BUILD A CABIN THIS SUMMER had pulled in more than 100 responses, and Sokol had chosen five canoe-club diehards for the privilege of doing hard labor. "We were all going to be learning how to build a cabin as we went along," he says. "What I wanted were people who were invested in the idea of building something beautiful and long-lasting."

Four of the students were engineering majors and one was double-majoring in physics and Asian and Middle Eastern studies. They ran snow-load and stress-load calculations, projected linear board feet of lumber and cubic yards of concrete and pored over a dog-eared copy of the *Log Construction Manual* by Robert Wood Chambers.

Once the crew peeled the bark off the logs, it was time to move them downstream—somehow. Among the students was Kate Bowman, a paddling, climbing and backcountry ski guide for Dartmouth's Outing Club. "When we couldn't figure out the answer to a problem," Bowman says, "our instinct was to go to the Internet. But so much of what we needed wasn't there." The crew studied old photographs to resurrect the classic New England river drive, which

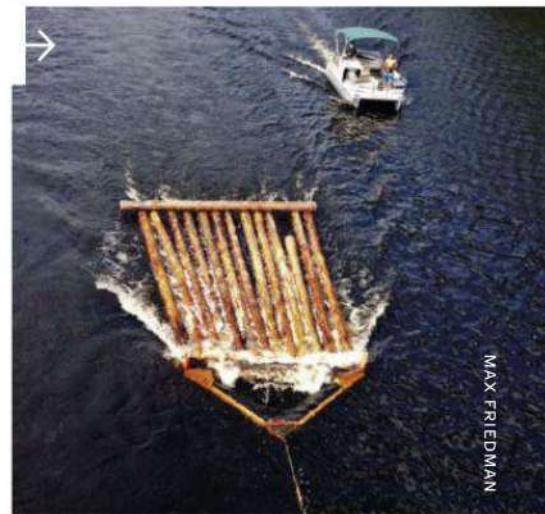


CHIMNEY SWEEP

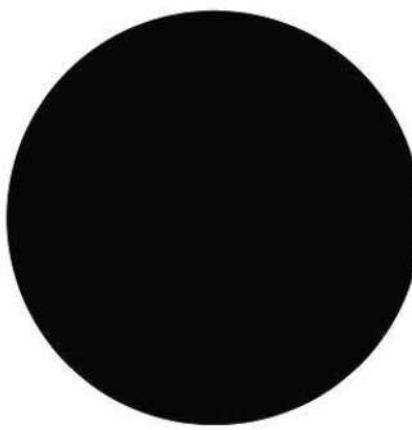
After fire destroyed the 57-year-old Titcomb Cabin, Kate Bowman pried away its chimney, preparing to rebuild.

DELIVERED BY RIVER

Dartmouth students studied archival photos of New England log drives to learn how to transport spruce and pine trunks to the site of burned-down Titcomb Cabin on an island in the Connecticut River. The crew peeled the bark from 97 trees, grouped the logs by size, rolled them to the river, and then used eyebolts and carabiners to clip them to a 2 x 4 frame. The debut eight-log run broke apart, but later drives hauled 12 and 16 logs per trip.



MAX FRIEDMAN



LUCAS SCHULZ

LOG FLUME

Greg Sokol guides a log up a 40-foot trough at the island's bank. The rig was dubbed the Death Slide after one log snapped the axle of a hand-cranked winch. The solution: A chain-saw-powered Lewis Winch that zipped logs up the slide in seconds. The crew also brought in a mixer and a generator—by canoe—and carried 52 80-pound bags of concrete from the shore.

CHAIN-SAW SUMMER

Lucas Schulz lops off a log butt with a Husqvarna 359 chain saw. All workers took chain-saw certification classes. "It was a decibellious day," Jordan Nesmith blogged.



had gone out of style with the advent of the automobile. On the first attempt, two logs floated free of their bonds. But a quick repair held, and the logs glided down the river toward Gilman Island.

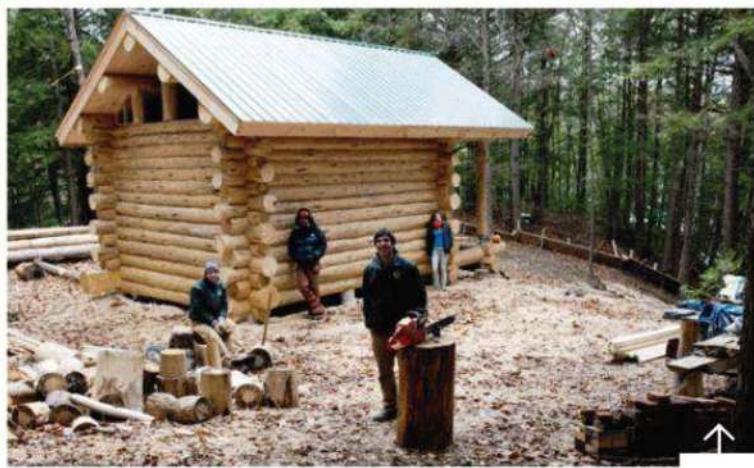
On the island, the students used a borrowed mechanical-advantage Grip-hoist to haul the logs up the steep bank to the site, in a 40-foot-long wooden trough they called the Death Slide. It took 20 laborious minutes per log. Next, they tried a long-handled come-along and snapped an axle. Finally, they settled on a chain-saw-powered winch they'd seen in the forestry-supply catalog that served as reading material in the privy. Anchored to a tree, powered by a Husqvarna chain saw, the winch could zip a log up the slide in 30 seconds.

OVER THE STEAMY NEW HAMPSHIRE summer, revived by daily swims in the river and immersed in the tangy scent of pine and the whine of two-stroke chain-saw engines, the students attacked the project with a mix of old and new technology. They used chisels and drawknives hand-forged by a blacksmith in Idaho and sharpened their tools with a barber's honing stone found on eBay. They fashioned hardwood handles and 60-pound log butts into mallets that could nudge the heavy logs the final inch into position. They ran foam strips between each course of logs to keep out drafts. They fired up a generator and used halogen lights to work after dark as they raced to get the metal roof in place.

Then, as the foliage peaked, classes resumed and the river turned cold, construction slowed. The crew would leave some work for 2011—installing the door, the windows and a wood stove—but Titcomb 2.0 already looked like a cabin. One day, Sokol took a break from trimming the roof to reflect. "We surprised ourselves," he said. "We were just an eighth of an inch out on the diagonal. It was within reason."

He had already begun planning a spring dedication event. He hopes Jack Titcomb's son, Peter, will be present. There will not, Sokol said, be a bonfire.

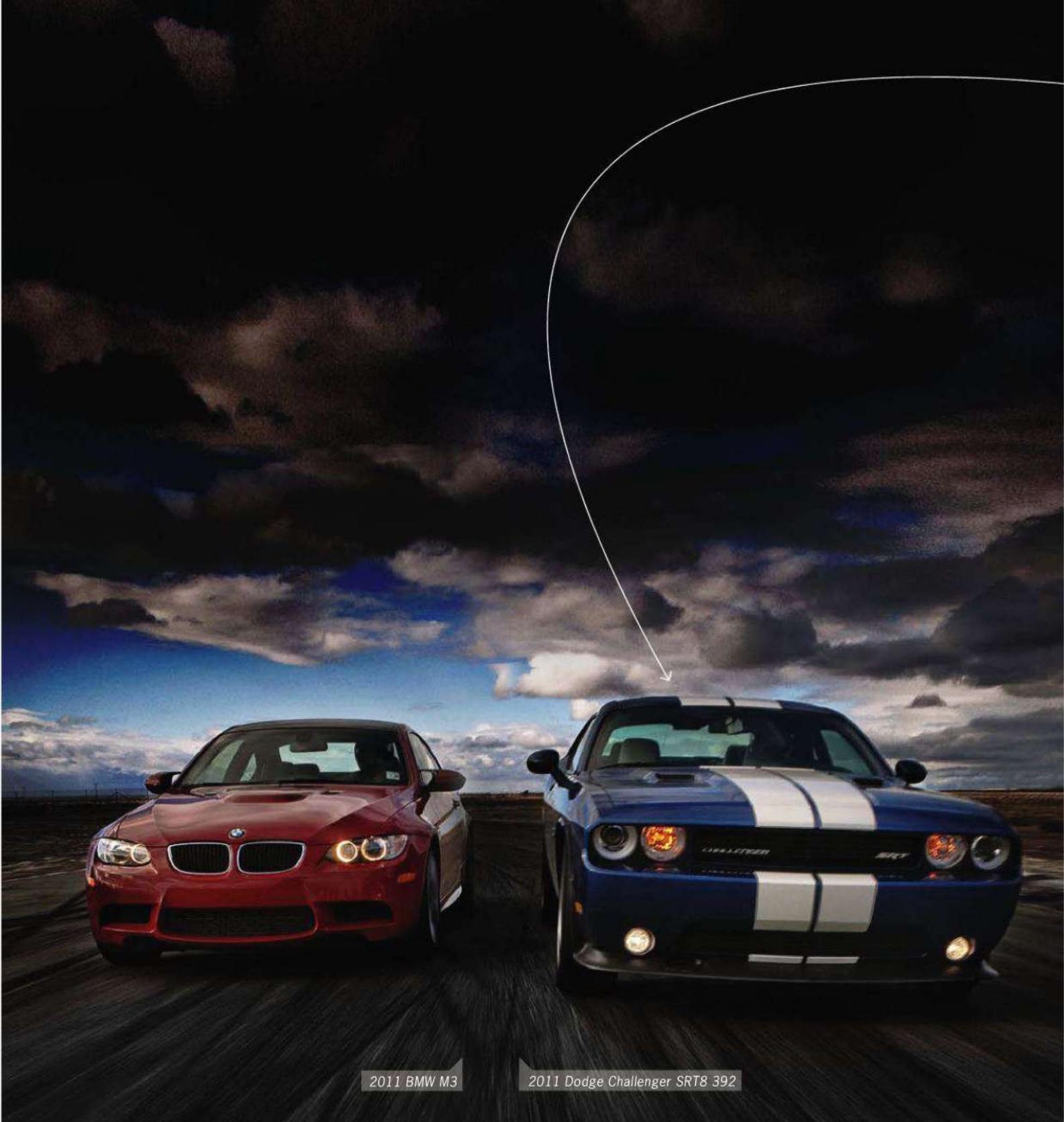
PM



BOBBY FISHER

CABIN CRAFT

From left, Parker Reed, Kodiak Burke, Greg Sokol and Kate Bowman. The crew practiced joinery on an 8 x 10-foot test structure before moving on to the main 14 x 23-foot Titcomb Cabin. The final product ended up measuring perfectly level at every corner.



2011 BMW M3

2011 Dodge Challenger SRT8 392



DETROIT vs THE WORLD

MOTOWN IS
GETTING ITS
GROOVE BACK,
BUT IS THAT
ENOUGH TO
TAKE ON THE
WORLD'S BEST
CARS? PM
INVESTIGATES.

PM TEST-DRIVEN

JUST TWO SHORT YEARS AGO, CHRYSLER AND GM—ONCE STALWART ENGINES OF AMERICAN manufacturing—were sputtering. Even after the controversial mega-billion-dollar bailout and massive restructuring, there was no guarantee we would buy their cars again. Since then, a significant and perhaps nostalgic truth has emerged: Americans still want to own American products. Lo and behold, GM, Ford and Chrysler have enjoyed double-digit-percentage sales growth over the past year. It seems that a concerted product-improvement effort by Detroit's Big Three has finally borne fruit, as higher J.D. Power quality rankings show. Still, we wanted to know: Could U.S. cars conquer their foreign rivals in real-world performance tests?

To find out, we pitted the feisty new Ford Fiesta against our favorite compact, the Honda Fit; Buick's spirited Regal CXL Turbo against the Infiniti G25, a benchmark sedan; and the 470-hp Dodge Challenger SRT8 392 against the powerful but lithe BMW M3. Full-throttle dragstrip runs, brake testing and lane-change maneuvering composed the baseline test. But each pair of cars also ran routes designed to reveal strengths and weaknesses particular to the class of vehicle. The M3 and 392 underwent arduous lap sessions at Buttonwillow Raceway Park, the 3-mile road course near Bakersfield, Calif. For the Fit and Fiesta, we mapped out an exhaustive 300-mile trek—through L.A. traffic snarls and along the Pacific coast's most demanding highways—to measure the compacts' fuel economy and pep. We hammered the sport sedans on the scenic (and sometimes dangerously curvy) canyon roads, high above the surf. Here's how this global showdown shook out.

BY BEN STEWART + PHOTOGRAPHS BY CHRISTOPHER WRAY-MCCANN

MIGHTY MITES

The Honda Fit proved that practical, pocket-size cars needn't be dull—and finally, a worthy alternative has emerged: the new Ford Fiesta.

E

ver since its U.S. debut in 2006, the funky, fuel-efficient Honda Fit—already a star in its native Japan and other foreign markets—has dominated the subcompact segment here. Reversing the formula, Ford revamped the Fiesta overseas, where it quickly developed a stellar reputation of its own, and then reintroduced the car domestically in 2009. (The original Fiesta was last sold in the U.S. in 1980.) So, now that we have a fair fight on our hands, we wonder: Is the new Fiesta, which was bred for zesty European roads, right for America, and can it stand up to the Fit? Let's hit the road to find out.

Flick either one of these spunky hatchbacks into a series of hard corners and they both channel the fun-loving spirit of an early-'80s VW GTI, the original hot hatchback. Though the Fit Sport nosed ahead of the Fiesta in our handling tests, on back roads the Ford actually feels more nimble and better suited to hard driving. Its 120-hp four-cylinder engine seems comfortable near the redline, singing a pretty tune when running wide open. The Ford's road feel is direct, neither too hard nor too soft, and the steering wheel itself is fat and purposeful—like one you'd find in a sporty (and much more expensive) coupe. When zipping through a turn, the Fiesta's chassis feels buttoned-down and offers less body roll than the Honda. The Fiesta invites you to drive aggressively, which you do, well, just because it's fun. The Fit is more workmanlike and aloof, with less fluid feedback from the asphalt. In Sport mode, the Ford's electronically controlled, dual-clutch PowerShift transmission chooses just the right gear for each corner, whereas the Fit's traditional five-speed automatic is less active and less finely attuned to the task.

The Honda fares better in traffic. Its tall roof and giant windshield create a vast, uninterrupted view, and the automatic transmission is so docile and obedient, you barely notice the shifting. In similar conditions the Ford's gearbox proves slightly sluggish, pausing a beat or two between shifts.

At the testing price of \$19,820, the Fit includes a navigation system that operates so intuitively your dear Aunt Edna would be an expert in seconds, while the Fiesta—\$19,960 as tested—seems almost designed to confuse, with a Learjet's worth of buttons crammed into the tiny dash space. Only Ford's techno trump card, the voice-activated Sync system, saves the driver from irritation.

Both of the hatchbacks can handle more stuff than their silhouettes suggest, although the Fit, with its high roof and flat-folding seats, fits more gear, more elegantly. It's clearly the workhorse of this duo. In fact, its boxy design may be one reason it lagged behind the Ford in our fuel-economy test; the sleeker Fiesta looks like it would slice through the air with less effort, using less fuel. The Fit returned 36.1 mpg overall, compared with the Fiesta's 38.9. Considered together, the Fiesta's hybrid-like efficiency, hip styling and fun-loving personality give it a clear advantage over the Fit.

TALE OF THE TAPE

SCORECARD		HONDA	FORD
Powertrain		W	
Handling		W	
Practicality	W		
Curb appeal		W	
Fuel economy		W	
Final tally	1	4	

2011
HONDA
Fit ✗
2011
FORD
Fiesta

Price (base/as tested)	\$19,110/\$19,820	\$17,120/\$19,960
Powertrain	117 hp/106 lb-ft 1.5-liter inline 4, 5A	120 hp/112 lb-ft 1.6-liter inline 4, 6M/A
Wheelbase (inches)	98.4	98.0
Length (inches)	161.6	160.1
Curb weight (pounds)	2620	2620
Acceleration (0–60 mph)	11.11 sec	10.86 sec
Acceleration (1/4 mile)	18.01 sec @ 76.2 mph	17.97 sec @ 78.9 mph
Braking (60–0 mph)	121.77 feet	119.69 feet
Slalom (mph)	40.86	39.38
Lane change (mph)	54.28	53.6
Skidpad (g's)	0.83	0.81
Fuel economy (mpg)	27 city/33 hwy	28 city/38 hwy
PM fuel economy (mpg)	36.10	38.90



Ford's Fiesta has a computer-controlled dual-clutch gearbox, just like the exotic Bugatti Veyron.

2011 Ford Fiesta

VS

2011 Honda Fit

The Fit carves out a surprisingly roomy interior from its small exterior.





The new
Regal CXL
Turbo
is the most
entertaining
Buick since
the GNX.

VS

2011 Infiniti G25

2011 Buick Regal CXL Turbo

No straight-
aways, no
problem! The
Infiniti G25
lacks torque,
loves curves.



CANYON CARVERS

At last, a Buick that's more sports car than cruise ship. But can the Regal steal the crown from the Infiniti G25?

S

ince the 1960s, sporty Buicks have been rare. In fact, the last one with any heat under the hood was the turbocharged, 276-hp GNX—24 years ago. The new Regal, also turbocharged, promises to change that.

On paper, the American stallion should have the edge from stoplight to stoplight. But even though the Regal packs 258 lb-ft of torque—71 lb-ft more than the G25—it beats the Infiniti by a mere .21 seconds from 0 to 60 mph. Still, the 220-hp Buick feels quicker, and we dig listening to the snorty turbo as it whistles and pops. The Buick's engine is the rebellious punk of this pair, a radical that also returns an excellent 27.1 mpg. Meanwhile, the Infiniti's 218-hp, 2.5-liter V6 is as exciting as a college professor's cardigan. Sure, it's velvety smooth and quiet (study hall, anyone?), but it left us wanting for torque and good, old-fashioned fun when we tried to wind it up.

Out in the canyons, the G25 shines. The chassis is fluid and balanced. It feels solid, like it could take the corner-carving punishment all day. The G25 uses the same basic chassis as the Nissan 370Z sports car—no wonder it moves so well. But you've got to keep that little V6 above 4500 rpm—and make sure the transmission is in the manual mode—or else the whole powertrain feels lethargic, as if every gear, rod and piston is coated not with some magical Lucas lubricant but with Elmer's Glue.

The Buick requires more work to drive fast, but, man, does it hustle. There's a lot of grip and razor-sharp turn-in from the 19-inch tires, and the torque reserve allows you to merely toe the throttle to set up for the next turn. It's a thrilling ride but ultimately less substantial-feeling than the Infiniti. The Regal creaks and groans over rough pavement; it's as if Buick had used a thinner grade of steel in its chassis. The Regal's steering and braking require little effort and are thus difficult to operate precisely. The Buick also seems to work hard to maintain its running speed, which the Infiniti does effortlessly.

Ultimately, the Regal has a higher fun factor, but the Infiniti, which has more significant bearing and pays better attention to detail, is more rewarding. Inside, for instance, the Infiniti is sharp and well-crafted. The Buick wears an attractive gauge cluster and splashes of tasteful chrome, but some of the trim feels less securely affixed than in the Infiniti; it's as if the Buick's fasteners could have used an extra quarter turn of the wrench on the assembly line. On a more important note, the Regal's infotainment system is so incredibly frustrating to use that we defaulted to iPhone navigation to get home one night.

In this battle the Buick gamely fought. The drivetrain was frisky and entertaining, the chassis athletic. Also, the Regal's crisply tailored design makes it the best-looking domestic sedan on the market. But the Infiniti simply handles better, is more polished and feels more expensive despite costing slightly less as tested. This was a heated contest, but the G25 refuses to surrender the sport-sedan throne to the Regal.

2011 INFINITI G25	X	2011 BUICK Regal CXL Turbo
Price (base/as tested)	\$32,350/\$34,225	\$28,745/\$35,380
Powertrain	218 hp/187 lb-ft 2.5-liter V6, 7A	220 hp/258 lb-ft 2.0-liter turbo inline 4, 6A
Wheelbase (inches)	112.2	107.8
Length (inches)	187.0	190.2
Curb weight (pounds)	3640	3780
Acceleration (0–60 mph)	8.44 sec	8.23 sec
Acceleration (1/4 mile)	16.14 sec @ 87.1 mph	15.84 sec @ 91.1 mph
Braking (60–0 mph)	115.71 feet	116.6 feet
Slalom (mph)	39.95	40.36
Lane change (mph)	56.07	56.07
Skidpad (g's)	0.84	0.82
Fuel economy (mpg)	20 city/29 hwy	18 city/29 hwy
PM fuel economy (mpg)	25.00	27.10

TALE OF THE TAPE

SCORECARD	
INFINITI	BUICK
Powertrain	W
Handling	W
Interior	W
Curb appeal	W
Value	W
Final tally	3 2

HORSEPOWER HEAVYWEIGHTS

Dodge's reincarnated and reinvigorated Challenger SRT8 392 faces off against a muscle car from a very different milieu, the BMW M3.

A

t first blush, comparing the BMW M3 to the Dodge Challenger SRT8 392 seems a bit like debating who's the better footballer, Peyton Manning or Justin Tuck—a lively tavern discussion but ultimately pointless. But on closer inspection, the two have more in common than simply playing on the same field. Like the Challenger, which predates the BMW by 16 years, the M3 is basically a muscle car, although one reflective of its Teutonic heritage.

In Germany, many drivers remove the badges from their cars to avoid being perceived as bragging about, say, the V12 under the Mercedes S600 hood. And so the M3's body differs minimally from its 3 Series brethren: The fenders flare just enough to accommodate the

larger wheels and sport suspension, and the one high-tech exterior detail—a carbon-fiber roof—is noticeable only upon close inspection. In the engine room, yes, there's a V8, but it's a peashooter by U.S. standards, displacing just 4.0 liters. It still delivers 414 hp, however, thanks to its high rpms. At 6000 rpm, where the typical V8 starts puffing, the M3's mill hums, building to a glorious 8300-rpm crescendo.

Meanwhile, the battleship Challenger (it's 16 inches longer and several inches wider than the M3) flaunts its firepower. The recessed grille, bulging flanks and bold stripes herald what lies beneath: a 6.4-liter Hemi V8 that bangs out 470 hp. Surprise, surprise—the Challenger's a pro at the stoplight drag dance. The clutch engages gradually, so the hulk launches from a standstill without roasting the Goodyears. The pistol-grip shifter, a vintage touch, is a fitting detail for this four-wheel magnum. The big V8's responsiveness and chest-thumping roar never fail to elevate the heart rate, and in every acceleration contest, the Dodge edged out the BMW: 0 to 60 mph in 4.74 seconds versus 4.87 seconds, and a quarter mile in 12.98 seconds versus 13.03 seconds. This might have been 1970 all over again, if not for the 392's commanding suspension and massive disc brakes, which make it more than a straight-line special.

The question is, how much more? The Challenger's hefty 4300 pounds—740 more than the BMW—hamper its overall achievement. (Unless you're a defensive end, weight can be the enemy of performance.) So, in the curves the M3 took charge, outshining the 392 in every handling test. More tellingly, the BMW sizzled the 3-mile Buttonwillow road course in 2:13.1, two seconds quicker than the Dodge, which over-worked the tires as it bounded around the track. The Challenger is improved for sure and still fun, but the M3 is like a freshly sharpened Wüsthof carving knife to the Dodge's dull meat cleaver.

All told, the margin is slight between the multitalented but discreet M3 and the charismatic, booming 392. But Dodge's engineers didn't simply reissue a classic. They polished the brawn just enough—for about 15 grand less than the M3. In this matchup, it's Detroit by a nose.

TALE OF THE TAPE

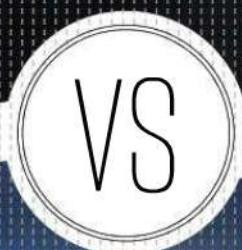
SCORECARD		BMW	DODGE
Powertrain	tie	tie	
Handling	W		
Interior	tie	tie	
Curb appeal	W		
Value	W		
Final tally	1	2	

	2011 BMW M3	X 2011 DODGE Challenger SRT8 392
Price (base/as tested)	\$58,400/\$67,025	\$43,380/\$48,515
Powertrain	414 hp/295 lb-ft 4.0-liter V8, 6M	470 hp/470 lb-ft 6.4-liter V8, 6M
Wheelbase (inches)	108.7	116.0
Length (inches)	181.8	197.7
Curb weight (pounds)	3560	4300
Acceleration (0–60 mph)	4.87 sec	4.74 sec
Acceleration (1/4 mile)	13.03 sec @ 109.95 mph	12.98 sec @ 110.43 mph
Braking (60–0 mph)	111.91 feet	113.43 feet
Slalom (mph)	42.82	41.53
Lane change (mph)	61.31	58.18
Skidpad (g's)	0.93	0.86
Fuel economy (mpg)	14 city/20 hwy	14 city/23 hwy
PM fuel economy (mpg)	20.80	21.05



Before battling
the Challenger,
you've got to
ask yourself one
question: Do
I feel lucky?

2011 Dodge Challenger SRT8 392



2011 BMW M3

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BY JOSEPH TRUINI

I've always loved the idea of a large garden filled with colorful flowers and luscious vegetables. But it always turns out to be too much work. Avid gardeners tell me that I'm missing the point, but spending weeks on my hands and knees yanking weeds and swatting away bugs isn't my idea of fun.

Then I discovered container gardening, the popular practice of planting in pots, trays, window boxes and other portable containers. What makes this appealing to me—and millions of others—is that it requires very little space and a minimal commitment of time. Plus, you'll never end up with mud in your shoes—or shorts (don't ask).

This planter trellis is my favorite container-gardening project. While

diy

Home



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it's designed for climbing vines such as clematis, nasturtium, pole beans or Boston ivy, it also makes an attractive privacy screen for a deck and can hide a pool pump or a propane tank. You could build it out of pressure-treated lumber, but we chose red cedar. This wood is easy to work with, and it takes stain beautifully. It should last for many years with little maintenance, so you can spend more time gardening and less time maintaining. Here's how to build it.

Building the Box

1 Begin by crosscutting the 1 x 4 tongue-and-groove cedar that is used for the planter box. I made gang cuts using a compound miter saw with a stop clamped to its fence [1]. This method ensures all the parts are accurately cut to the same dimension. Lacking a miter saw, you could carefully measure, mark and cut the parts freehand with a circular saw using a crosscut guide. I also crosscut the cleats that the planter rests on and the horizontal trim to which the tongue-and-groove pieces are nailed.

Use exterior-grade glue and 1½-inch finish nails to assemble the planter box panels. Fasten the tongue-and-groove pieces to the horizontal trim using a pneumatic finish nailer [2]. Position the rough-sawn surface of the tongue-and-groove pieces so they face the outside of the planter box and face-nail through the back of each piece into the trim. If you don't have pneumatic tools, use glue and 3d hot-dipped galvanized finish nails.

Next, fasten the cleats to the front and back panels using 2½-inch decking screws [3]. Note that the bottom of the cleats is not flush with the bottom of the panels but is offset by 1 inch.

With the panels completed, assemble the planter box by attaching the panels to each other. Drill pilot holes, then drive 2½-inch trim-head screws through the front into the side panels [4]. Do the same to attach the back to the sides. Once the box is built, lay the bottom slats in and fasten them



[1] Crosscut the tongue-and-groove pieces. To ensure the parts are a consistent length, use a stop held to the fence. [2] Rip the end pieces of each panel to width, then align the tongue-and-groove pieces over the exterior trim. Make sure to position the rough-sawn face to the outside (face down). [3] Once the front and back panels are completed, screw a cleat to the inside face. Note that the cleat's bottom edge must be positioned below the panel's bottom edge. [4] Assemble the box body by screwing the panels together. Next, fasten the bottom slats to the cleats. [5] Complete the planter box by joining the rim pieces with pocket screws; nail the completed rim to the planter box.

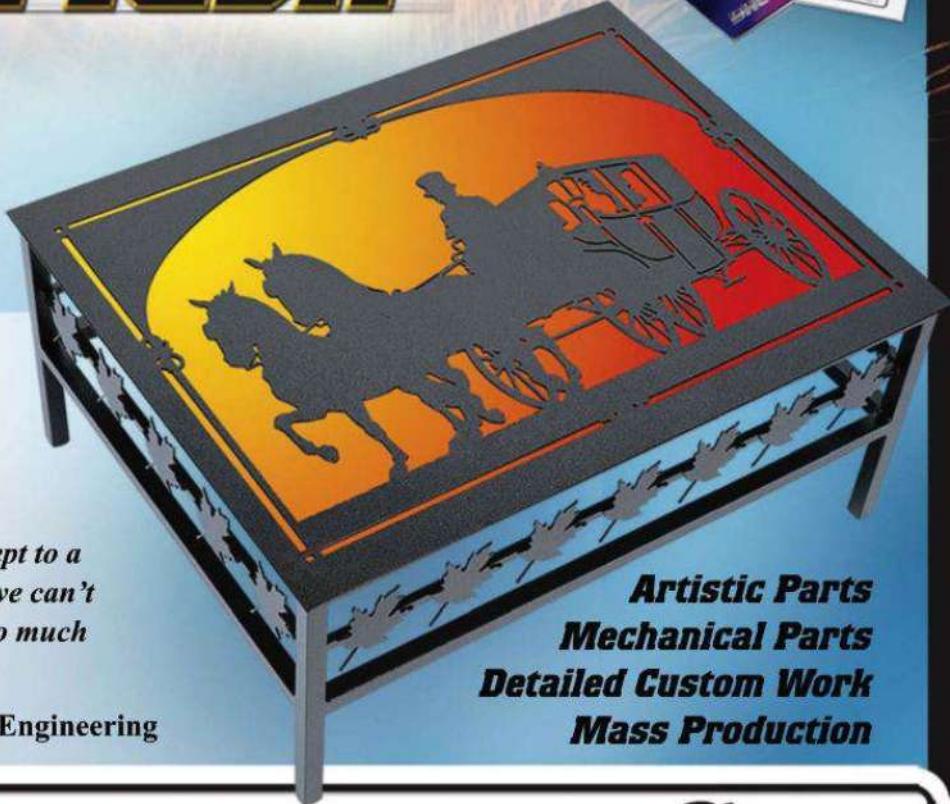
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to the cleats with 1¼-inch nails.

The planter box rim consists of four 1 x 3 pieces joined with pocket screws. Crosscut the pieces, bore the holes into them, and join the pieces with 1¼-inch coarse-thread pocket screws. Place the completed rim on the box with an equal overhang. Fasten the rim

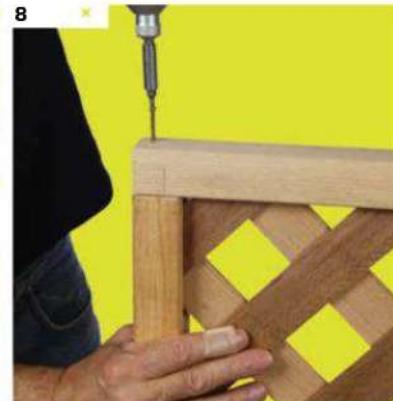
to the top of the box with 2½-inch pneumatic nails or 8d galvanized finish nails [5].

Add the Lattice

[6] The lattice frame is simple to build, but you should note that the frame's groove is handled three different ways. In the top horizontal frame member, the groove is stopped at both ends. In the bottom horizontal member, the groove runs out both ends. In the two

vertical frame members, the groove runs out the top and is stopped at the joint where the part meets the horizontal frame member.

Crosscut the frame members, and cut the grooves into the pieces using a dado blade in the table saw [6]. To cut a stopped groove, make a registration mark on the side of the workpiece that indicates where the groove stops. Likewise, with the dado blade raised to the depth of the groove, mark the



[6] Rip grooves into the lattice frame with a dado blade on the table saw. Use a pushstick as you near the cut's end or when starting a stopped groove.

[7] Screw the lattice uprights to the lower crossbar, then slide the lattice into the groove. [8] Screw on the upper crossbar, then nail on the lattice trim cap.

Construction Details

Parts being fastened	Fasteners	Direction of fasteners
→ Lattice upright to upper box	1¼"-dia 3½" galvanized carriage bolts	Through horizontal trim on back panel, through lattice upright
→ Lattice upright to lower box	1¼"-dia 3" galvanized carriage bolts	Through back of box, then through lattice upright
→ Tongue-and-groove panel pieces to horizontal trim	1¼" pneumatic finish nails	Through inside face of panels into trim
→ Cleats to front and rear box panels	2½" decking screws	Through cleat into inside face of front and rear panels (seven screws per cleat)
→ Front and rear box panels to side panels	2½" exterior-grade trim-head screws	Through horizontal box trim on front and rear panels into horizontal box trim on side panels (four screws per corner)
→ Slats in bottom of box to cleats	1¼" pneumatic finish nails	Through slats into cleats (six nails per slat)
→ Front and rear box rim to side box rim	1¼" coarse-thread pocket screws	Through side rim into front and rear rims (two screws per joint, eight total)
→ Box rim to front, rear and side panels	2½" pneumatic finish nails	Through rim into panels
→ Lattice upright to lattice crossbar	2½" exterior-grade trim-head screws	Through side of lattice upright into end of lattice crossbar (two screws per side, four total)
→ Upper lattice crossbar to lattice upright	2½" exterior-grade trim-head screws	Through top of crossbar into end of lattice upright (two screws per joint, four total).
→ Trim cap on lattice frame to upper lattice crossbar	1¼" pneumatic finish nails	Through top of trim cap into horizontal frame



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- Kidney or liver problems
- Blood problems, such as sickle cell anemia or leukemia
- A deformed penis, Peyronie's disease, or an erection that lasted more than 4 hours
- Stomach ulcers or any kind of bleeding problems

Tell your doctor about all your medicines. Include over-the-counter medicines, vitamins, and herbal products. Tell your doctor if you take or use:

- Medicines called alpha-blockers to treat high blood pressure or prostate problems. Your blood pressure could suddenly get too low. You could get dizzy or faint. Your doctor may start you on a lower dose of VIAGRA.
- Medicines called protease inhibitors for HIV. Your doctor may prescribe a 25 mg dose. Your doctor may limit VIAGRA to 25 mg in a 48-hour period.
- Other methods to cause erections. These include pills, injections, implants, or pumps.
- A medicine called REVATIO. VIAGRA should not be used with REVATIO as REVATIO contains sildenafil, the same medicine found in VIAGRA.

POSSIBLE SIDE EFFECTS OF VIAGRA

Side effects are mostly mild to moderate. They usually go away after a few hours. Some of these are more likely to happen with higher doses.

The most common side effects are:

- Headache
- Feeling flushed
- Upset stomach

Less common side effects are:

- Trouble telling blue and green apart or seeing a blue tinge on things
- Eyes being more sensitive to light
- Blurred vision

Rarely, a small number of men taking VIAGRA have reported these serious events:

- Having an erection that lasts more than 4 hours. If the erection is not treated right away, long-term loss of potency could occur.
- Sudden decrease or loss of sight in one or both eyes. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. They may be caused by conditions like high blood pressure or diabetes. If you have sudden vision changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Sudden decrease or loss of hearing. We do not know if these events are caused by VIAGRA and medicines like it or caused by other factors. If you have sudden hearing changes, stop using VIAGRA and all medicines like it. Call your doctor right away.
- Heart attack, stroke, irregular heartbeats, and death. We do not know whether these events are caused by VIAGRA or caused by other factors. Most of these happened in men who already had heart problems.

If you have any of these problems, stop VIAGRA. Call your doctor right away.

HOW TO TAKE VIAGRA

Do:

- Take VIAGRA only the way your doctor tells you. VIAGRA comes in 25 mg, 50 mg, and 100 mg tablets. Your doctor will tell you how much to take.
- If you are over 65 or have serious liver or kidney problems, your doctor may start you at the lowest dose (25 mg).
- Take VIAGRA about 1 hour before you want to have sex. VIAGRA starts to work in about 30 minutes when you are sexually excited. VIAGRA lasts up to 4 hours.

Don't:

- Do not take VIAGRA more than once a day.
- Do not take more VIAGRA than your doctor tells you. If you think you need more VIAGRA, talk with your doctor.
- Do not start or stop any other medicines before checking with your doctor.

NEED MORE INFORMATION?

- This is only a summary of important information. Ask your doctor or pharmacist for complete product information OR
- Go to www.viagra.com or call (888) 4-VIAGRA (484-2472).

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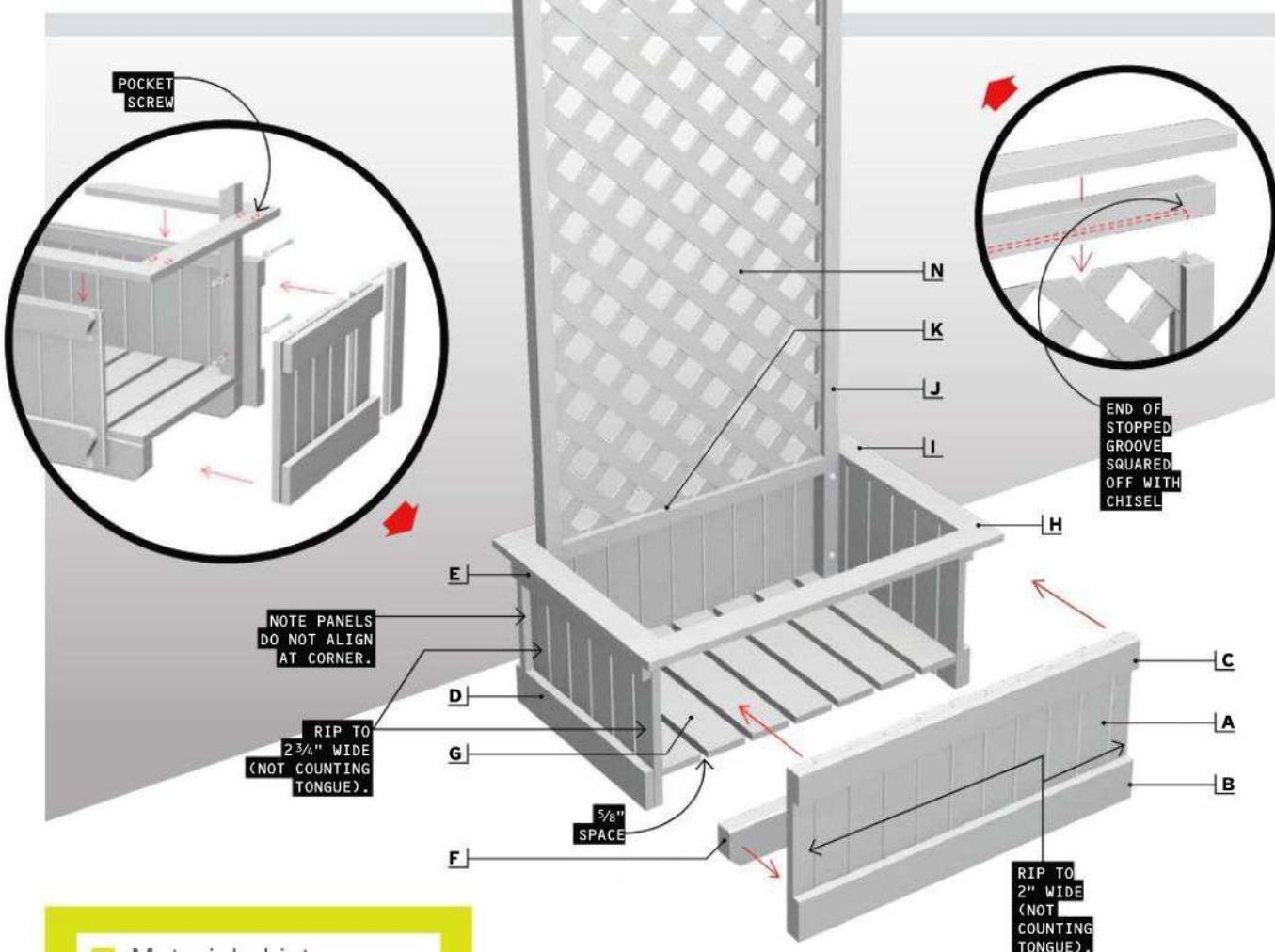
diameter of the saw blade on the saw table (the position of the front tooth and the back tooth). Stop cutting a groove when the registration marks are aligned. If you're experienced with a table saw, you can begin a stopped groove by carefully pivoting the workpiece down along the side of the fence and onto the dado blade (known as a plunge cut). If the thought of that makes you uneasy, align the registration marks and raise the blade into the

workpiece. Square off the end of a stopped groove using a chisel.

With the frame parts grooved, fasten the sides and bottom pieces together using 2½-inch trim-head screws [7]. Cut the lattice to length using a fine-tooth metal-cutting blade in a jigsaw. This reduces the likelihood

PM DIY HOME // TRELLIS PLANTER

of cracking or splintering one of the lattice slats. Slide the lattice into the groove and fasten the crossbar [8]. Attach the cap on top of the lattice frame. Finally, clamp the lattice assembly to the planter box and bore the bolt holes for mounting the frame, then bolt the lattice to the box. **PM**



Materials List

Key	No.	Size and description
A	34	1" x 4" x 14" cedar tongue and groove (box panel)
B	2	1" x 4" x 31" cedar (box trim)
C	2	1" x 3" x 31" cedar (box trim)
D	2	1" x 4" x 17½" cedar (box trim)
E	2	1" x 3" x 17½" cedar (box trim)
F	2	2" x 4" x 28" cedar (cleat)
G	7	1" x 4" x 17½" cedar (bottom slat)

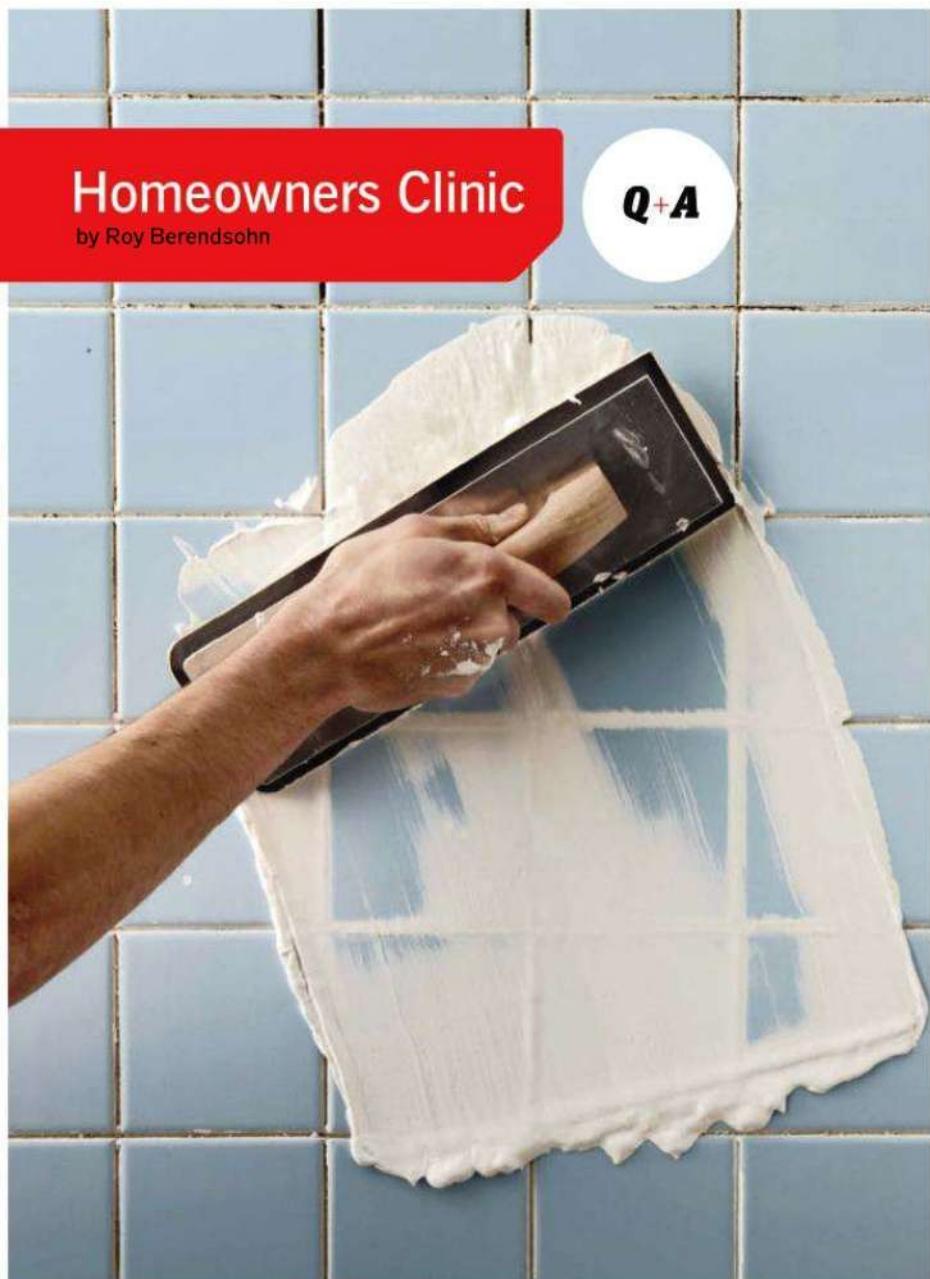
Key	No.	Size and description
H	2	1" x 3" x 33" cedar (rim, front/back)
I	2	1" x 3" x 17½" cedar (rim, side)
J	2	2" x 2" x 58½" cedar (lattice upright)
K	1	2" x 2" x 25¼" cedar (lattice crossbar, lower)
L	1	2" x 2" x 28¼" cedar (lattice crossbar, upper)
M	1	1" x 4" x 29¾" cedar (lattice trim cap)*
N	1	½" x 26" x 47¾" cedar (lattice)

* Note: Rip piece to 3".

Homeowners Clinic

by Roy Berendsohn

Q+A



Q

Grout Cleanout

Our bathroom is in pretty good shape because we redid it several years ago, but I'm not happy with the way the grout on the tub walls is holding up. I've already had to touch it up in several places. I want to regROUT because the bathroom sees a lot of use and I don't want tiles falling down. What's the best grout to use, and what can I do to ensure the new grout lasts as long as possible?

A Smart move to regROUT before larger damage is done. Grout that's crumbling and mildew-stained is more than unattractive; it's mechanically unsound and will only continue to crumble unless it's removed and replaced.

A common cause of grout failure is that the installer used too much water

Replacement grout should be creamy—thick enough to stick to the wall yet thin enough to spread easily and flow between tiles.

in mixing a cement-based material. "That will create a weak and powdery grout joint," according to Patrick Allen, senior technical representative at Laticrete International in Bethany, Conn., which makes grouts, mortars and related materials.

Also keep in mind that some grouts need to be moist-cured. It's not difficult—all you have to do is mist the tile and grout with water from a spray bottle. A sheet of plastic taped in place and draped over the wall holds in the moisture during the curing process. Other grouts need to be coated with a sealer recommended by the grout manufacturer.

And while it's tempting to use an inexpensive, commodity grout when a heavy-duty version is called for, it's false economy. While a 25-pound bag of cement-based grout might cost \$12 to \$15, a polymer-modified version of the same product, complete with antifungus additive, may cost about twice that. The grout will look better and last longer. The polymer improves the grout's water resistance and makes it more flexible so the grout can withstand temperature fluctuations and wall movement.

Finally, thoroughness counts. "The more careful you are with each step in the replacement process," Allen says, "the longer the grout will last and the less maintenance it will require during its lifetime."

Follow these steps to ensure a long-lasting and good-looking grout job:

1. Buy enough. Don't get caught short. Use any one of the several grout calculators or charts online to estimate how much grout you need. Better to have a little too much than not enough.

2. Clean. Thoroughly remove any mildew and soap scum before cutting grout out of the joints.

3. Remove. Cut out grout to at least

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half the depth of the tile.

4. Angle. Apply the replacement grout at a 45-degree angle to the tile. Work it thoroughly into the spaces between tiles so there are no air bubbles or gaps.

5. Wipe. Remove as much excess grout as possible while it's wet. It's easier to do at this stage than when it's dry.

6. Caulk. Apply a high-quality tub-and-tile sealant where the wall meets the tub and in vertical corners where one wall meets another.

Steel Door Repair

The outer glass pane on my steel entry door is broken. Even if I could figure out how to get the glass out of the door, I haven't had any luck finding replacement glass for it. Please help.

You can buy replacement glass on the Internet, but you should try local sources first. If you haven't already, I'd visit or call old-fashioned full-service lumberyards, or window and door dealers. Once you have the glass, though, installing it is usually a 15-minute job.

"The most important thing is to properly measure for the replacement," according to Lisa Devin, a sales representative for Peasedoors.com, an online retailer based in Cincinnati. In most cases, you measure the rim that holds the glass, since the rim and the glass are sold as one assembly. There are rims on both sides of the door, and both should have the same dimensions. Measure their length and width from the outside corners (not the inside). This is different from the procedure that you use for measuring the glass for some windows and wood doors. In those cases, the measurement is made of the glass itself. Always double-check with the glass supplier, though.

Next, remove the caps over the rim screws on the inside of the door and back the screws out. Remove the outside rim and the glass, which are usually held together with sealant. Now have someone hold the new glass and rim from the outside while you fasten the new inner rim by driving the screws that came with it.

The job is slightly more complicated for readers who want to replace broken or warped rims over decorative glass. In that case, you remove the inner rim and squeeze a tape measure between the door and the glass. Order the replacement based on the rim size and the thickness of the glass, which will be $\frac{1}{2}$, $\frac{3}{4}$ or 1 inch thick. Cutting away the sealant so that you can remove the outside rim from the decorative light can be tough. It requires some patient scraping and prying to free the rim from the glass. If you want to replace warped or cracked rims on clear glass, it's easier to just replace the glass and rim at the same time.

Web Master

We have a cathedral ceiling in our living room, and there's a corner of the ceiling where mildew forms and cobwebs gather. The rest of the ceiling is fine, but not this one corner. What causes this, and what can we do to prevent it?

Assuming that there isn't discoloration in the corner that indicates a roof or wall leak, then my hunch is that it's just dead airspace. Air currents move over the ceiling and then curve down along the wall,

SHOPPING LIST

DON'T FORGET THE OTHER STUFF

→ You need lots of tools and materials to produce a strong and long-lasting grout joint. Here's a sampling.

A
Silicone tub-and-tile caulk:
Apply at wall corners or where the wall meets the bathtub.

B
Grout enhancer:
Instead of water, mix this with grout to improve its durability and stain resistance.

C
Grout:
Use sanded for wide joints ($\frac{1}{16}$ to $\frac{1}{8}$ inch), unsanded for narrower joints.

D
Cleaning supplies:
Cleaner and sponge for removing soap scum, hard-water deposits and mildew.

E, F
Floats:
Use hard rubber (E) for applying epoxy grouts; use soft sponge rubber (F) for standard grout.

G
Rubber gloves:
Spend a little more for heavy-duty tile work gloves, not the dishwashing variety.

H
Scrub brush:
Removes grout dust after joints have been cut out.

I
Grout saw:
Cuts failed grout out of joints.

J
Tile sponge:
Wipes off excess grout.

Not shown:
Buckets, soft cotton rags, kneepads for regROUTing floors.



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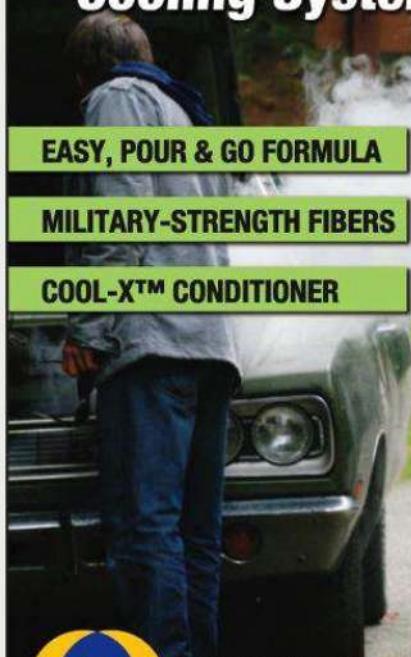
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bypassing the corner. That dead air space is why you should never locate a smoke detector near the corner of a wall or ceiling. There's no smoke there during a fire. Dust and webs form rather than being flushed off the surface, and this creates a growing medium for mold. The effect is more pronounced when a textured ceiling traps dust.

A corner formed by exterior walls can be particularly vulnerable to condensation and dust collection because it's a cool spot. The wall framing at the corner is nearly solid lumber; it has virtually no insulation. It gets even worse if an air-conditioning vent shoots cold air into the space, making condensation on the opposite wall more likely.

There isn't much you can do about this phenomenon. Operating ceiling fans might help to break up pockets of stale air, but your best bet is probably to keep an eye on the area and clean it regularly with a dust mop on the end of an extension pole. Get up on a ladder

every so often and wipe the wall and ceiling surfaces with a cleaner rated as a fungicide/mildewcide.

Tripped Up

I have a GFCI outlet that has me confused. It started to open, and I thought the reason was that I was charging cordless power tools, so I unplugged them. The outlet continued to open, so I replaced it. The new outlet has the same problem. Thoughts?

I get more Clinic mail on GFCIs (ground fault circuit interrupters) tripping than I do on any other electrical problem. They trip in the presence of an extremely small imbalance of incoming and outgoing current in the circuit (in the range of 6 millamps). An imbalance of current is created when it flows outside its normal path. Instead of current flowing safely back to the service panel on the neutral wire, it's leaking out somewhere. It could leak out through you when you

come in contact with a metal part, or it could travel along without anybody noticing until the GFCI trips.

Given that you've already replaced the GFCI and are experiencing the same problem, it's unlikely that the GFCI is to blame. It will take some methodical detective work to find the problem.

First, I'd cut power to the circuit and look for damaged insulation between the hot conductor (a black or red wire) and a neutral (white) or ground wire (bare or green). This could allow current leakage where the two wires touch. Failing that, another common problem is a sloppy splice that has left exposed conductor under the twist-on wire connector. Current flows where hot and neutral (or ground) splices come in contact. In a similar fashion, a sloppy splice or damaged insulation can allow leakage current against a metal box that houses an outlet, switch or light fixture.

Also, old refrigerators have been known to leak current from the mullion heater (the heater that warms the metal between the freezer and fresh-food cabinets to prevent condensation) or the defrost heater. The current can run from the appliance's frame to the body and can even travel along a damp concrete floor in a basement or a garage. We've often had mail from people who receive a shock while reaching for a cold beer or can of soda (especially likely if their hand is sweaty from doing yardwork). They report that the problem is not consistent enough to track down. Obviously, it only occurs when they reach for the beverage and the mullion heater or defrost heater is energized.

Finally, it's also possible that a number of devices on the same circuit that the GFCI is serving have leakage currents that are below the GFCI's threshold yet produce cumulative leakage sufficient to cause the GFCI to trip. This is especially likely if the GFCI is wired into a very large circuit, serving a number of outlet receptacles (the more receptacles on the circuit, the greater the chance of cumulative leakage).

It's Creepy and It's Spooky

What do you do to work in a crawl-space? I hate working down there and want some tips to make it easier. My house is built above a dirt-floor



NOW YOU KNOW

SHINE ON

12-GA. COPPER WIRE

→ I've got all kinds of worklights. Some clip on or hold with a magnet and others simply dangle. I even have power tools with lights built in. They all work great because I don't think one light works for all situations. My favorite, though, is to use the pen light shown with a piece of 12-ga. copper wire. Bend the wire into a coil, loop it around the light's barrel and you've got a light on a stand for really tight spots. You can also bend the wire around something and hang the light down, allowing you to light a spot that's nearly impossible to illuminate using conventional methods. Better yet, this little setup uses a scrap material. It's no big deal if the copper breaks or it's lost or even if I have to cut it down to fit. There's always another scrap piece to be had.

crawlspace, and I'm planning to get in there and seal a damaged vent and support some pipes.

I own a house with a creepy crawlspace as well, so I know what you mean. I wish future building codes would just outlaw them. Eventually, they'd go the way of the outhouse.

Grumbling doesn't help matters. There are several things I do to make working down there a little easier. First, I carefully inventory all the tools I'll need and stage the tools at the entrance. When I crawl through the entrance, I turn right around and drag in the tools behind me. That way I don't start work and find I'm missing an important tool. Among the stuff that I bring in with me is a wide plank to lie on while I'm working and a rolled-up towel on which to rest my head. Next, I dress appropriately for the environment. I wear coveralls, kneepads and safety glasses. If I'm doing something dusty, I wear a dust mask. If the crawlspace is really disgusting, with lots of dangling spider webs, I even put on a spray sock, a disposable one-piece hood that you can wear when you're

spraying paint or insulation.

Crawlspaces are obviously dark places. I don't skimp on bringing work-lights and flashlights down with me. You'll find that you're more productive working in a well-lighted area, and it just makes the space feel less creepy.

Finally, if you haven't already covered the crawlspace floor and part or all of the foundation walls with a vapor barrier, then you need to do so. The standard for vapor barriers in the past was a sheet of 6-mil plastic with its seams overlapped and taped. Today, thicker and less permeable sheets are used; it's not unusual to see 12- and 20-mil vapor barrier coverings. These are sold at specialty supply houses, at some lumberyards and on the Internet.

Mystery Leak

We have a leak that shows up on the downstairs kitchen ceiling, and I suspect it could be from an upstairs bathroom that was redone about three years ago. On the other hand, it could also be a roof leak because there's a weird roof intersection nearby. How do I track this down?

Good question. If the wet spot manifests itself soon after someone takes a bath or a shower, then a tub or shower drain or a leaking supply line are likely sources. If you use another bathroom in the house and find that the wet patch dries out (and there hasn't been any rain), then it's likely that the drain is the problem, since a leaking supply line will keep the area damp. It's also possible that a poorly caulked joint along a tub or around a faucet escutcheon is to blame. Other leak sources are poorly soldered or defective plumbing valves. If the roof is not steep, give it a thorough inspection. Pay extra attention to valleys where roof planes meet and where a roof abuts a chimney or a wall. Also look for loose or damaged shingles.

PM

Got a home-maintenance or repair problem? Ask Roy about it. Send your questions to pmhomeclinic@hearst.com or to Homeowners Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.



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PM Saturday

1 → GATHER PARTS I designed a mobile bench because the projects I build on my webcast, *The Ben Heck Show*, typically happen in locations without a shop. To build it, first use a table saw to cut a 4 x 4-foot sheet of $\frac{1}{2}$ -inch plywood into panels at the dimensions shown. Obtain two cabinetmaker's cup hinges (Salice or Blum brands work), four 1 x 1-inch leaf hinges, a box of 1-inch No. 6 wood screws, a $\frac{1}{4}$ -inch combination drill bit and countersink, a 6-inch metal handle, wood glue, eight rubber feet and magnetic cabinet latches.

2 → BUILD THE BOX Drill mortises and mount the cup-hinge hardware to attach the main work surface (C) to the base of the unit (E). Rout a recessed grip into the outer face of C. Mount the left and right flaps (A and B, respectively) to both sides of C using screws and 1-inch hinges. Plan the larger flap (B) to open on the side of your dominant hand.

Make sure A and B fold flat atop C. Next, drive 1-inch wood screws through the sides (D) into the base and top (F). Drive 1-inch screws through the back (G) to secure the sides. Mount magnetic latches under the top. Check to make sure the hinge knuckles at each edge of C clear the sides and that the latch acts as a stop for A, B and C when the box is closed. Mount the handle. Fasten the magnet latches' mates to the faces of A and B. Add feet to the outer faces of E and C.

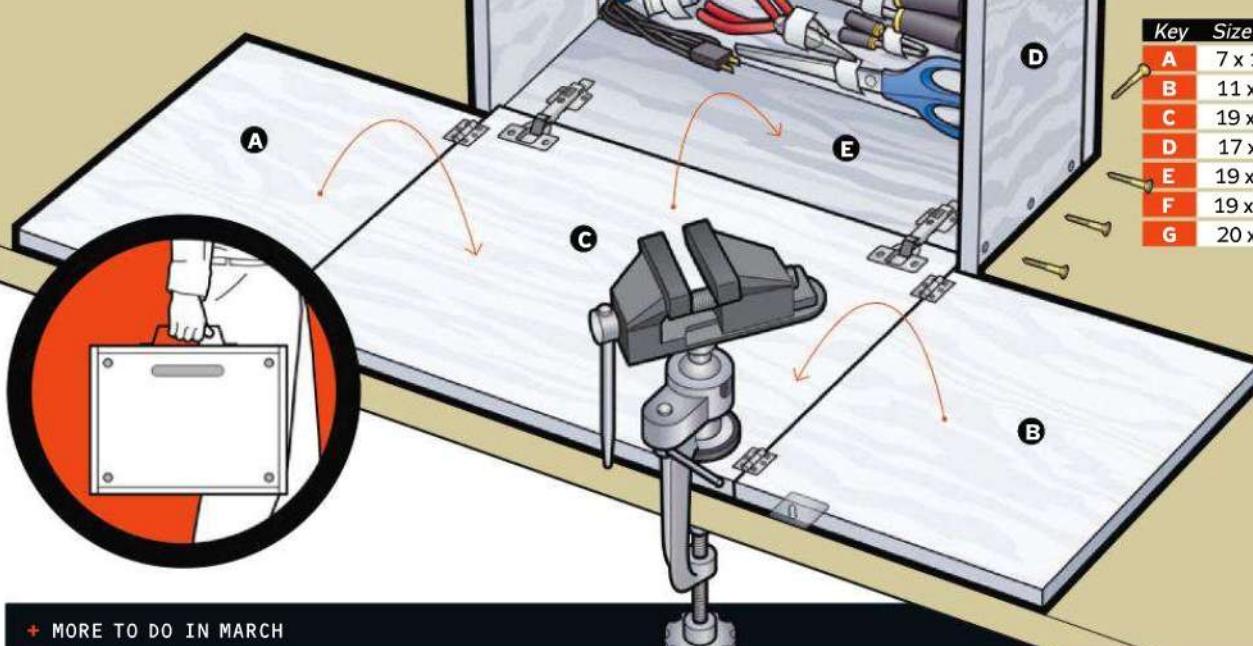
3 → STOW TOOLS Add Velcro strips to store tools along the back panel. I often do electronics work, so I carry a small multimeter, a soldering iron, wire strippers, pliers and tweezers. Any kit should have a hobbyist's vise, which I use to grip small parts. When working on a tabletop, the vise's attachment clamp can stabilize the bench itself. Other good all-purpose items include screwdrivers, a flashlight, calipers and scissors. My hot-glue gun sees a lot of action—bring an extension cord and a power strip if you'll need electricity on the go.

+ ONE-DAY PROJECT

Instant Workbench

THIS SUITCASE-SIZE BOX UNFOLDS INTO A WORK SURFACE AND A SQUARE FOOT OF HARDWARE STORAGE. BUILD IT AND TAKE YOUR TOOLS ON TOUR.

BY BEN HECK



+ MORE TO DO IN MARCH

Inspect the Deck →

Virginia deck- and dock-cleaning expert Keith Quinn says March is the perfect time to prep the deck. "Don't use bleach to clean it," he says. Use an oxidizer, like OxiClean. Need a pro? Look up Wood Re New.

Adopt an Engine →

Find antique gas-powered washing machines, corn grinders and mowers aplenty at the Marshall County Antique Power Association Swap Meet in Moundsville, W.Va.'s fairgrounds on March 26.

Prep the Lawn →

"Wait for the lawn to thaw before you start throwing stuff on it," Needham, Mass., lawn guru Garrett Graham says. He uses Mag-I-Cal fertilizer, then spreads grass seed once soil temps top 55 degrees.

Reclaim the Garage →

Each spring, Pete Foster of *Garage Slab* magazine says he power-washes the garage floor and cleans the wheels and tracks on garage doors. "Think up when it comes to storage," Foster says.

Wish Welders Well →

The Tulsa Welding School attracts student metalworkers in droves to its two welding competitions—Feb. 26 in Tulsa, Okla., and March 5 in Jacksonville, Fla. Entrants receive a \$500 TWS scholarship.

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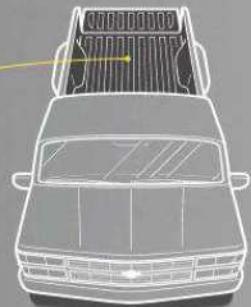
degree of difficulty

EASY



Brush-in Bed Liner

CHERRY OUT THE INSIDE OF YOUR PICKUP AND PRESERVE THE METAL BY ROLLING ON A RUBBERIZED LINER. BY MIKE ALLEN



➲ I've always wondered why pickup trucks have painted beds. Hauling anything immediately scratches a brand-new truck bed. It's slippery as heck when wet. Of course, there are alternatives: Old trucks used to use wood, which rotted in a few years. You can buy a drop-in plastic bed liner, but it might rub off paint and trap moisture underneath, which leads to rust. I'm starting to think the best solution is an applied surface that's tougher than paint, like an epoxy concrete-floor coating. In



Start at the front of the bed and work to the back to keep clear of the wet area.

INSIDE



OIL CHANGE—OR NOT? + LOOSE NUTS + SLIMY STEERING WHEEL

ILLUSTRATION BY MERCÈ IGLESIAS

the industry, these coatings are called spray-in bed liners, and there are several companies that will coat your bed. Using catalyzed-urethane-based polymers at 800 to 2000 psi, these liners are thicker and tougher than the driveway-applied roll-in liners—they're also considerably more expensive, with prices ranging from \$400 to nearly \$1000. This is a perfect DIY project: In only 4 hours, we did the job ourselves for about \$50. Here's how.

It's All in the Prep

Start by washing the truck, paying special attention to getting the inside of the bed squeaky clean. Skip the wax setting at the quarter car wash, because the bed-liner material needs bare, clean paint to stick. Give the box a full day to completely dry.

Find a shady, outdoor place. Trust me, you won't want to work indoors—

this stuff stinks like dead dinosaurs when it's drying.

Wear old clothes. And old shoes. Rubber gloves are a very good idea because it takes days to come out of your fingerprints. (Don't ask.)

Use a leaf blower or a shop vac to clean the inside of the bed of any dust, leaves or water. If you've spilled any oil, ever, it'll need to be cleaned with mineral spirits. If there's any loose, peeling paint or rust on the sheet metal, you'll need to wire-brush, sandpaper or sandblast down to clean metal. Don't leave any loose rust around. Then blow out or vacuum the debris again. Prime the bare spots with a zinc-based primer, which you can spray from an aerosol can or even brush on.

More Helpful Hints

You'll need to apply two coats. Do both

on the same day, but wait long enough, an hour or two, to allow the first coat to set up. Wait too long and the second coat may not bond properly. Achieving a consistent texture isn't trivial. It's a constant juggling act between having enough and too much material on the roller, rolling out what's there and backtracking to catch drips. Watch any inner corners, seams or fittings, as the liner material can sag several minutes later. No problem—just roller over it and catch the drips. Again, patience is the watchword. Use mineral spirits or lacquer thinner to clean up any spills.

Remove the masking tape within 4 hours or so. Let the bed dry for about 24 hours, longer if the weather is cool.

Be aware that the intense flat-black color of your liner will fade within a few months to charcoal gray. But then, so will the expensive spray-in liner. **PM**



THE NITTY-GRITTY

BRUSH ON, ROLLER ON

The real secret to doing a proper bed-lining job is patience. Don't rush initial cleanup or proper scuff-sanding. Bonus: You can use leftover coating to touch up scratches periodically. If so, don't forget to degrease the surface before recoating.



1. Once the bed is clean and dry and any bare steel is primed, mask off the bed tops, the tailgate, the hinges and the latch pins. Careful masking will considerably improve the aesthetics of the job.

2. Scuff the entire interior of the bed with either the kit's Scotch-Brite pad or some 150-grit sandpaper. Be thorough or the new liner will peel off in sheets later.

3. Here's an example of paint that's been scuffed properly. There will still be some shine, but you definitely need to leave a patina of scratches behind. I recommend a dual-action or orbital sander for most of the job and saving the Scotch-Brite for the inside corners.

4. The second coat will show a uniformly rough high-traction surface left behind by the roller. Texture areas you can't roller by dabbing with the end of the slightly wetted brush.

5. Using a disposable brush, touch-paint any inside corners where the roller won't fit. Starting at the front of the bed, roller on the liner material. For the first coat, you won't see the final texture, so simply concentrate on getting an even coat without any missed spots, drips or sags.

6. Use solvent and fresh paper towels to degrease the bed.

It's vitally important to get every inch. Change the toweling when it looks dirty. Wipe in only one direction, from the front of the bed to the back, to keep any greasy spots from migrating to the back. Needless to say, work out of doors for this step.

Car Clinic

by Mike Allen

Q+A



38% OIL LIFE
REMAINING
P R N D L

Countdown

→ GM cars use a complex algorithm to calculate remaining oil life. Engine temperatures, crankshaft revolutions and other factors all influence the oil's usefulness.

3000 or Not

How much should I trust the oil-life monitor in my Chevy? Would you feel comfortable waiting until it says that there's 5 percent oil life left, or would you change it earlier—at, say, 30 percent? Or should I just stick to a 5000-mile change routine and adjust for harsh driving conditions?

A GM's Oil Life System is actually far more than a simple mileage tracker, and usually, it's very effective. Usually. It works by counting crankshaft revolutions and recording engine parameters such as hot and cold engine temperatures as well as a number of other factors, depending on the engine family. The purpose of all of this is to predict when the ZDDP (zinc dialkyl dithiophosphate) antiwear additive in the oil is exhausted, at which point engine wear accelerates. ZDDP prevents metal-to-metal wear in areas where the oil film may not be adequate and extreme pressures—like the pointy end of camshaft noses sliding over flat tappets—force the film completely out from between sliding metal surfaces. There's far more to engine-oil exhaustion than ZDDP levels, but GM has found it's the single largest

predictor of oil condition.

Unfortunately, the algorithm can't account for a leaky air cleaner that lets in airborne dirt, coolant weeping into the cylinders, a tankful of bad gas, excess crankcase condensation from a stuck thermostat or a hundred other mechanical woes not related to the oil itself. Oil contaminated with dirt, water, coolant, bypassed exhaust gases or unburned fuel—none of which can be accounted for in GM's algorithm—will accelerate engine wear.

GM's method is good, but it's potentially more accurate to directly measure the oil's condition rather than simply infer it. Mercedes' system uses a sensor that determines the dielectric constant of the oil, a measure of the oil's ability to resist electrical fields. (Dielectric constant by itself has no bearing on the actual capacity of the oil to protect

your engine, but as the oil is contaminated with dirt, wear particles, water and partially burned hydrocarbons, it changes.) BMW uses a simpler resistance-based sensor. These systems are more attuned to measuring the contaminants that build up in the oil, rather than being concerned with the depletion of ZDDP. There are other systems in commercial use, but the common thread is that they have a better chance of finding used-up oil than GM's predictive algorithm does.

On the other hand, if you're confident that everything under your hood is going according to plan, the GM Oil Life System can be a useful tool, and I'd wait until the Oil Change message appears or the percentage of oil life left is a single digit before changing the oil and filter. The day of the preemptive 3000-mile oil change is dying fast.

Power to the People

Our business uses several Chevrolet 1-ton 15-passenger vans that are all less than 4 years old. We often travel on gravel and muddy roads, and when we do, the vans lose all power, as if there's a 2.5-hp lawnmower engine under the hood. I am fairly sure this has to do with the traction-control system. Is there a fuse that we can pull to disengage the traction control, or do you have another idea to fix this?

The perceived loss of power is exactly how traction control is supposed to act on slippery surfaces. The system prevents excess wheelspin by rapidly pulsing the brakes and, if needed, interrupts engine power by rolling back ignition timing and shutting down injectors. Some drivers in trucks of your vintage also report loss of power on bumpy (not slippery) roads, but that doesn't seem to be your issue.

There are two ways to defeat the traction control. Pulling the appropriate fuse will also deactivate the antilock brakes, so don't do that. Instead, simply press the TRAC button on the dash until

the TRAC light (a yellow icon that looks like a little spinning tire) in the instrument panel comes on, signifying that the traction control has been disabled.

The traction-control system will reset itself the next time the key is cycled; you'll need to disable it every time you turn off the pavement. There's really no way to disable it permanently.

Sticky Fingers

Our '97 Dodge Ram 1500 pickup has an airbag in the steering wheel. The plastic covering has turned into a gooey mess. It's sticky, and the black color comes off on anything that touches it. This is the only part of the dash that has this problem, so it's obviously made of a different material than the rest of the interior. Do you know of any way to reverse this problem? Since it's an expensive replacement item, we don't want to do anything that would make it worse or make it fail.

The vinyl cover has started to depolymerize from environmental factors. That goo is the vinyl plastic and its plas-

tizers breaking down, and there's really no fix for it other than to replace the vinyl cover. It's a different grade of vinyl because, unlike the dash and door panels, it has to burst open easily to let the exploding airbag out. Dodge says the cover is separately serviceable in only 15 minutes without replacing the airbag module. Unless you've been trained at deactivating airbags, don't attempt this repair yourself.

Voltus Interruptus

I don't get all the hype about the Chevy Volt. Let's do some math here. The battery stores 16 kilowatt-hours of electricity, so charging it costs \$2.08 (assuming 13 cents per kWh). Based on your tests, the Volt can travel 35 miles until the battery is drained. Once the gas engine kicks on and the Volt enters the charge-sustaining mode, the car gets roughly 31 mpg. On gasoline, the Volt costs \$2.93 to go 35 miles (gas at \$2.60 a gallon), so the electric mode is less than a dollar cheaper to go 35 miles.

So what is the point of all of this

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PM DIY AUTO /// CAR CLINIC Q+A

engineering, complicated circuitry and heavy batteries? Shed the weight of the batteries and electric motor and I bet the fuel economy will improve enough to equal the EV per-mile cost. Not to mention the hours it takes to charge the batteries. Why don't they just build a fuel-efficient small-gas-engine car and drive it?

Your point is well-taken. Except that the Volt uses only roughly half of its 16-kwh battery pack. The Volt's battery-management system doesn't fully charge or discharge the pack, to optimize battery life and achieve GM's 10-year battery guarantee. So traveling 35 EV miles expends only 8 kwh, not 16. Factor in 10 to 15 percent losses (as heat) during the recharge cycle and you'll draw about 9 to 10 kwh for a full recharge. Also, the DOE says residential electricity averages 11.53 cents per kwh, not 13. And the average U.S. price of gasoline is closer to \$3, not \$2.60. That makes the cost of the electricity to propel the Volt 31 miles \$1.15, and the

cost of the gasoline \$3.38. So, your figures are off by a factor of nearly three.

All EVs and PHEVs are similarly careful with their batteries because deep-discharging or fully charging substantially reduces battery life. Your numbers might make sense if the cost of gasoline drops *and* electricity goes up. I'm guessing gas will continue to creep upward. And as it does, the Volt and its kin will make more sense.

As always, your mileage may vary. One example would be the Mazda2 currently in PM's press fleet, which consistently delivers 35 to 38 mpg in gnarly NYC commuting without the benefits of any hybrid gewgaws. Chevy's Cruze, built on the same platform as the Volt, is comparable. I think for many potential Volt owners, it's an opportunity to investigate the edge of the technology envelope. And don't forget, just as the Prius has gotten more efficient with every generation, so will the Volt.

Dewy-Eyed

My wife's 1996 Ford Taurus with a 3.0-liter V6 has what I think is an intermittent coolant leak. A small puddle appeared under the driver's



TOOL OF THE MONTH

STAYIN' TOGETHER



Chemical threadlockers are a great boon. They keep nuts from coming loose at inopportune moments, like braking into a turn at 160 mph or losing the hitch ball on the trailer at 4 am on I-80 in the middle of Nebraska. Traditionally they've taken the form of a liquid or gel, which is applied to the threads as the parts are assembled. Loctite's QuickTape 249 is a threadlocker that comes in tape form. And it's applied just like Teflon pipe tape—two wraps are plenty. Now you can assemble the part or wait as long as a month. QuickTape 249 makes working in tight places or overhead simpler, because the chemical stays put. And it's just as effective as the old-fashioned liquids.

side bumper after the car sat overnight. Then the weather got warmer, and the puddle stopped. I figure dew or frost had been melting and simply dripping onto the driveway. This morning, the first frost of the year, the puddle returned. Normally it is a very small puddle (6 inches), but this morning, it's rather large. The coolant overflow tank level is unchanged.

Check the actual level of coolant in the radiator, not in the coolant overflow tank. A poorly sealing radiator cap or a plugged hose between the radiator and the tank could cause coolant to vent without changing the level in the tank. Assuming what you're seeing is actually coolant, that is. Touch it with your finger and see if it smells sweet or very bitter. Coolant is sweet, although nowadays a lot of it is embittered to keep children or animals from drinking it.

I think your first assessment is correct: The wet spot emerges from condensation collecting in the bodywork and dripping onto the driveway. If so, it will be odorless, because it's basically just distilled water. Long shot: It's transmission fluid or power steering fluid, either of which would be oily.

SpongeBob

I have a 1996 Dodge Grand Caravan. I just replaced the front brake pads and rotors, the rear shoes and the right rear brake line. I then bled the brakes, starting with the wheel that's farthest away from the master cylinder. When I finished, I pushed on the brake pedal and it felt nicely firm. But when I started the engine and pushed on the brake pedal, it went almost to the floor. I also heard a hissing sound. In case it helps: When I turn the ignition key on, the ABS warning light comes on, along with the other warning lights, and when the engine starts, the ABS light goes out.

The ABS light is supposed to illuminate when you turn the key on before the engine starts. That's to confirm that the bulb hasn't burned out. It doesn't go off until the ABS hydraulic unit and computer have completed their POST (power-on self-test), which involves a quick test of the electronics, followed by cycling the pumps and hydraulic valves. This is to make sure everything

is working properly the next time some kid on a skateboard zooms out from between two parked cars.

Here's what happened: You flushed most of the air out of the system when bleeding, but left a small bubble inside the ABS, in an area where it didn't cause enough of a pressure differential to turn on the ABS warning light. When you started the car, the ABS controller tried to pressurize that bubble and turned it into highly compressible froth.

You could try repeated bleeding interspersed with cycling the ABS unit, but the prescribed way to bleed the brakes is to use a scan tool that supports the ABS on your minivan. Unfortunately, there aren't a lot of those tools around, except the very expensive ones the dealer and better repair shops have.

Pushover

While I was in college in the late '60s to the early '70s and living in the state of New Jersey, we had a flood. A friend drove his early-'50s standard-transmission Chevrolet van (with the three-speed on the column) through the water, which got into the clutch and locked it up. He could start it in gear, but when he stepped on the clutch, it would not disengage. If he started it in neutral, he could not put it into gear. A garage said it would cost some \$100 to \$200 (which was a lot of money at that time) to remove the transmission and take the clutch apart.

After thinking about it for a while, we jacked one rear wheel of the van up on his bumper jack. I told him to start the van in second and push the clutch in and hold it down to the floor. Then I told him to keep the clutch pushed in and rev the motor a little above idle. I then just pushed the van off the bumper jack. The jarring when the wheel hit the ground broke the rusted clutch loose. His eyes about popped when he realized that he did not have to remove the clutch or transmission.

And I'm guessing that that van had a host of other problems within a few months—stuff like a failed pilot-shaft bushing, a failed throw-out bearing, rusty brake linkage and other issues—as a result of the water infiltration.

Actually, it's not uncommon for

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clutches to seize up on cars that have been parked for too long, especially in damp areas.

Here's a better way to break one loose: Find a big, deserted parking lot or country road. Drive along at high revs in bottom gear and hold the clutch pedal to the floor. Lift off the throttle abruptly, then press the throttle to the floor. Repeat the on/off throttle action a few times. I've never needed more than a half-dozen stabs at the gas pedal to free one up.

Think about it: You can't put more torque on the clutch than the wheels have grip. Knocking it off the jack only gave you one shot at breakaway. My routine adds multiple shocks, and in alternating directions.

Oh, yeah—it's safer too.

Flicker, Flicker Little Northstar

Can you please tell me what would cause the oil light to flicker on and off when the coolant temp reaches 222 degrees? The engine is a 4.6-liter V8 GM Northstar with 97,000 miles. All other parameters—cooling fans, coolant and oil capacity—are okay.

Well, seeing as how the oil light is there to tell you when the oil pressure is too low, it's probably because: The oil pressure is too low.

Hotter oil = thinner oil = lower pressure in the oil gallery. Oil pressure is normally at its lowest at idle, when the oil pump is spinning slowly. Oil pressure also drops significantly when the oil gets really hot, which is normal—the Northstar is engineered to run properly with hot, low-viscosity oil. But at a certain point, when oil delivery is marginal, the pressure drops low at idle—low enough to flicker.

First step is to use a mechanical gauge tied into the oil pressure sender to confirm the low pressure shown on the dashboard. An acceptable reading on the mechanical gauge would mean a bad sender. Sender okay? Then start looking for a worn-out oil pump, a stuck relief valve or some other mechanical cause, like worn bearings.

Wrong-Way Montana

What damage would you look for if the serpentine belt had been installed the wrong way and the car was run 1000 miles? (It's a 1999 Pontiac Montana.) Could this damage the alternator?

Yes. It's possible (on some vehicles) to misroute the serpentine belt and actually get the vehicle to run. Odds are that the belt will not be correctly tensioned. If it's too loose, the belt will slip, squeal and allow the accessories to run too slowly because of the slippage. And it's sometimes possible to force a belt on so tightly that the spring-loaded belt tensioner bottoms out, overloading the belt. Potentially, this could damage the bearings in the water pump, power steering pump, air-conditioning compressor—and alternator.

That's why all cars have a correct belt-routing diagram under the hood and in the owner's manual.

Free Electricity!

I have a 2011 Jeep Grand Cherokee. The lights flicker (dashboard, headlights, interior lights) when the car is running. I took it to the dealer and the mechanics could see them flicker, so they hooked it up to the computer and said they found no problem. They said all the new Cherokees do this because they don't have an alternator. I don't buy it. Do you have any answers?

My answer is to go to a different dealer.

Of course it has an alternator. And flickering lights are not normal. This is a diagnosis that doesn't necessarily involve hooking the car up to a computer or a scan tool. You've got a bad alternator (potentially caused by a bad diode), bad regulator, faulty wiring or a bad connection. If the alternator checks out, look for a poor connection in the

Got a car problem?

Ask Mike about it. Send your questions to pmautoclinic@hearst.com or over Twitter at twitter.com/PopMechAuto or to Car Clinic, Popular Mechanics, 300 W. 57th St., New York, NY 10019-5899. While we cannot answer questions individually, problems of general interest will be discussed in the column.

battery wiring. Don't forget the grounds. A mechanic with a \$20 multimeter should be able to diagnose this in 10 minutes.

Water Crisis

I have a problem with corrosion around the overflow tank for the radiator.

When I had the dealer drain the cooling system I gave him 3 gallons of distilled water to use instead of tap water. Is this a good idea?

Yes, but if your water isn't very hard it's

not necessary. If you do have hard water, it'll help. And if you can't manage to get some distilled or demineralized water, at least avoid using water from the water softener, which replaces the calcium in the well water with sodium, which is probably worse than the calcium. Another option is to buy pre-diluted coolant. I prefer to flush the last bit of old coolant out of the engine with distilled water, though. Then add the right amount of undiluted coolant, and top it off with more water.

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diy

Tech

Start a Web Business

THE JOB MARKET IS TOUGHER THAN EVER, BUT STARTING YOUR OWN BUSINESS ONLINE HAS NEVER BEEN EASIER. HERE'S HOW TO GET A GOOD IDEA OFF THE GROUND.

BY JOHN HERRMAN

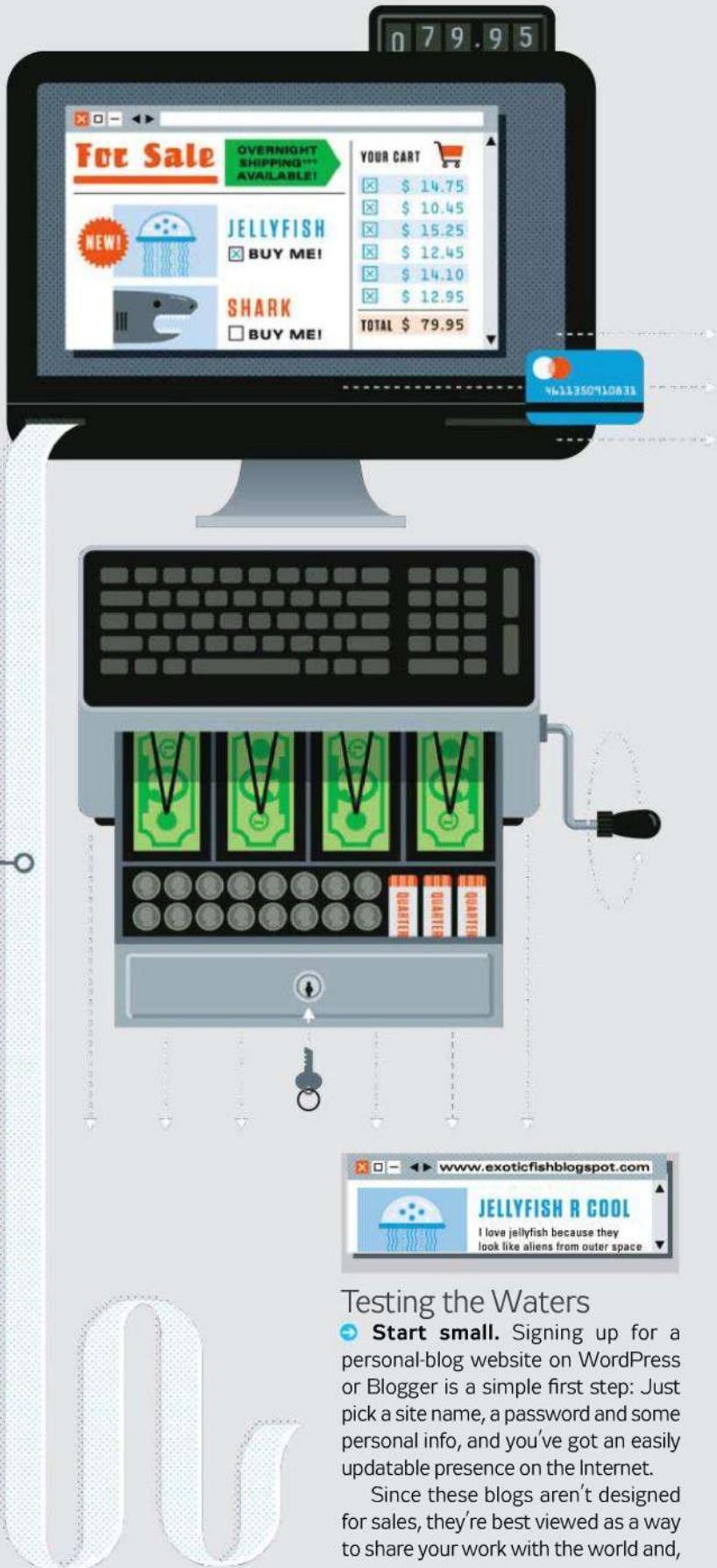
Alex Andon wasn't

thrilled to lose his biotech job in May 2008. But unlike most of the 2.6 million others laid off that year, he knew exactly what to do next.

"I was a marine biology major in college, and I had some pretty cool fish tanks. I had noticed that jellyfish exhibits had become popular at aquariums," he recalls. "People were mesmerized, but there was no way for someone to keep their own jellyfish, because they need special tanks and special food. If I could build one and supply the food, I knew there was a market there."

Nearly two years later, selling jellyfish tanks through JellyfishArt.com is Andon's full-time job.

In years past, starting a business was a complex, expensive and risky affair, but online tools have smoothed out many of the logistical bumps in the process. We've gathered wisdom from ordinary joes who made good by using the Internet to sell their wares. Here's how to get started.



Testing the Waters

• **Start small.** Signing up for a personal-blog website on WordPress or Blogger is a simple first step: Just pick a site name, a password and some personal info, and you've got an easily updatable presence on the Internet.

Since these blogs aren't designed for sales, they're best viewed as a way to share your work with the world and,

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more specifically, to gauge interest. Find relevant communities and message boards online. See if anyone else is selling similar products, and to whom. Whether you craft wood or machine metal or knit kitten scarves, you're guaranteed to find like-minded people online. With your new site, you'll have something to show them.

"The best way to get started is to put up a simple website and see how it goes," says Limor Fried, who founded Adafruit Industries, which specializes in do-it-yourself electronics building kits. Personal blogs require no financial outlay, are easy to update with photos and descriptions of your work and can even net a few informal sales through PayPal. "Adding PayPal buttons for payment is very easy," Fried says. "That's how I started out."

Zach Smith's MakerBot Industries, a New York City-based company that sells kits to build low-cost rapid-prototyping machines—also known as 3D printers—got his start the same way. "At the beginning, it was very much a 'Send me 10 bucks over PayPal, and I'll mail you this thing' type of arrangement," he says. This was fine, up to a point. "Beyond 30 or so orders, it gets unwieldy. But at the beginning it's great, because it requires almost zero effort to find out if anybody is interested."



Setting Up Shop

• **If you sense demand,** there are two options for turning a marketable hobby into a real online business: shacking up with an established site, or striking out on your own. Which strategy you pick depends on how easy you want the process to be versus how much independence you're looking for.

The buyer-and-seller culture on eBay is old and established but can be intimidating; a new seller can easily get lost in the overwhelming noise of the auction site. Amazon will let you sell under its banner, providing a free online storefront and order processing. (For the privilege, Amazon's commission can run as high as 15 percent.)

In recent years, a new breed of websites for selling homebuilt products has stormed the scene. Among the most popular is Etsy, which caters to the DIY set, with a special focus on crafts and art. Setting up an Etsy.com storefront is free and takes just minutes. Like Amazon, Etsy handles the entire transaction process, from credit-card processing to shipping calculations, though its fees are lower (listings cost 20 cents per item, plus a 3.5 percent transaction fee on anything sold).

A site called Big Cartel does Etsy one better with a service called Pulley, for selling downloadable goods like music, photography, videos or software. Pulley's flat monthly fees start at \$6, which gets you 25 product listings.

Stores such as this are easy to set up and pretty much take care of themselves, but they aren't for everyone. Commissions and fees can choke profits, and being part of a larger site hinders growth as an independent brand. Selling through Amazon or Etsy can feel more like renting a table at a flea market than running your own business.

The alternative? Running a website of your own.

The raw materials that go into a website are cheap to acquire. First, you'll need to find a host for your site. With reputable companies such as Network Solutions and Go Daddy, \$20 a month will get you enough space and bandwidth to get started. These sites will also sell you a domain name—a dot-com address of your very own. Unless a domain is already taken, it shouldn't cost more than \$20 a year.

Now comes the hard part: building a site. Major Web hosts sell cheap packages designed specifically for small-business owners, which include pre-designed site templates, shopping-cart software and options for customizing layouts without the need for HTML expertise. Some companies, like Volusion, specialize in prefab hosting and website packages for small businesses. Andon sells his jellyfish tanks using Volusion. "I have no knowledge of programming or coding," he says, "yet I was able to build my site on my own."

For a truly custom website design, expert help is a must. Freelancer.com, a bidding market for freelance develop-

ment work, is a good place to start. Freelancer.com's thousands of listed projects are also an invaluable resource for understanding how much Web design actually costs. (Fair warning: It can cost upwards of \$1000.)

Of course, all of your work will be for naught if you can't get paid for it. And the Internet has taken the pain out of accepting credit-card payments, even for brand-new businesses. PayPal offers a free basic merchant account, with no minimum revenue requirements and no need for a credit check, plus simple tools for linking it to common e-commerce platforms. PayPal's commission is reasonable, too, at 2.9 percent of each sale plus 30 cents per transaction.



Adjusting to Growth

• **Every small-business owner** plans to grow, or at least hopes to. Few know what to do when it actually happens. "As far as the biggest shock in running Adafruit goes, it was demand," Fried recalls. Zach Smith came to a similar realization in MakerBot's early days: "One of the pitfalls is that you start doing something, then you get successful, then you have to start building infrastructure and logistics. If you don't have help, the rest of the business suffers." The pressures of properly incorporating a business, figuring out taxes and dealing with customers can eclipse your core duties.

If it comes time to hire temporary help for shipping or menial tasks, Smith recommends Intuit's online payroll service, which keeps track of payments and automates the complicated paperwork generated by the freelance hiring process for around \$40 a month.

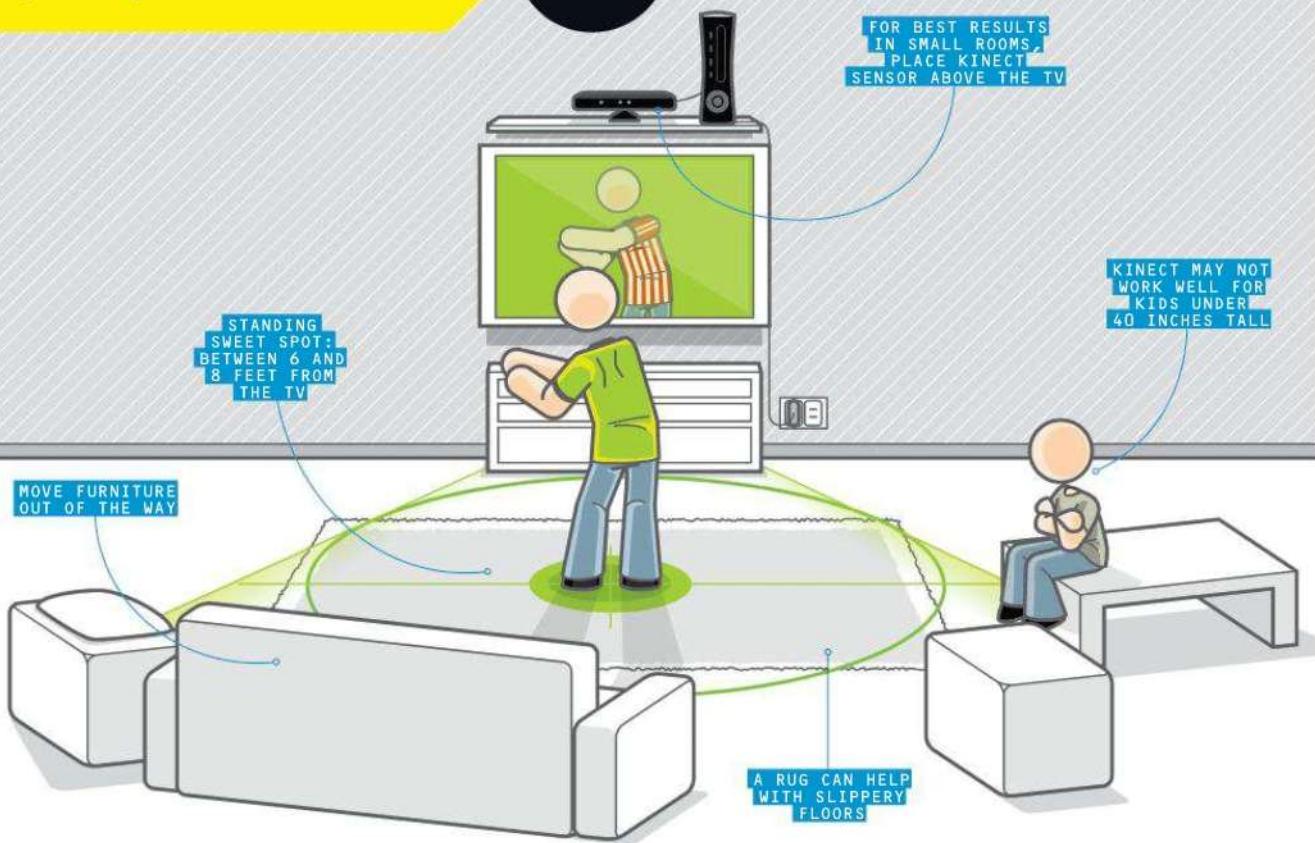
When the logistical demands start to become overwhelming or inventory begins to take up too much physical space, it's time to outsource. Amazon rents space in its massive shipping centers and will handle small businesses' packaging and shipping duties as well. The more you ship, the less you pay. And once you're shopping for warehouse space, maybe it's also time to move out of the garage.

PM

Digital Clinic

by Seth Porges

Q+A



Making Room for Kinect

I heard the new Microsoft Kinect may require users to rearrange their living rooms. If I buy one, what exactly will I need to do to make sure it works well in my space?

A For all the hubbub about Nintendo's motion-sensing Wii (remember the Wii?) getting gamers off their couches, the vast majority of the system's games don't require much physical exertion beyond a few well-timed flicks of the wrist.

So perhaps the greatest innovation of the Microsoft Kinect—the new Xbox 360 peripheral that uses depth-perceiving cameras to scan your entire body for controller-free, arm-flailing gaming—is that, at least with certain

games, you really can break a sweat. (Seriously, try playing *Dance Central* for more than a few minutes.)

But while button-mashing games can be played in pretty much any room, without much regard for anything else, making the most of your Kinect can take some prep.

First rule: The smaller the room, the higher you'll need to place the sensor bar. If you're blessed with a large, open playing space, you can probably get away with placing the sensor on your

TV stand below the set, but if you're playing in cramped confines, try to position the bar somewhere between eye level and 6 feet in the air. "Height gives the camera a better view of your body when you're standing closer to the camera," says Josh Hutto, Microsoft's director of marketing for Xbox 360. Several third-party accessory-makers now make wall mounts, TV clamps and freestanding floor stands to help keep the sensor afloat.

Next, you'll want to clear out as much furniture as you can. Couches, coffee tables, ottomans, Greco-Roman sculptures—they can all block the Kinect's view of your room and even cause injury if you happen to bump into them while in the throes of a *Kinect Adventures* tournament (YouTube is full of hilarious examples of such mishaps). For most people, this game of musical chairs (or, rather, musical furniture)

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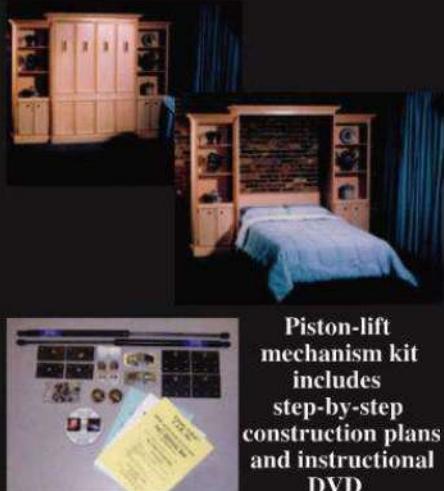
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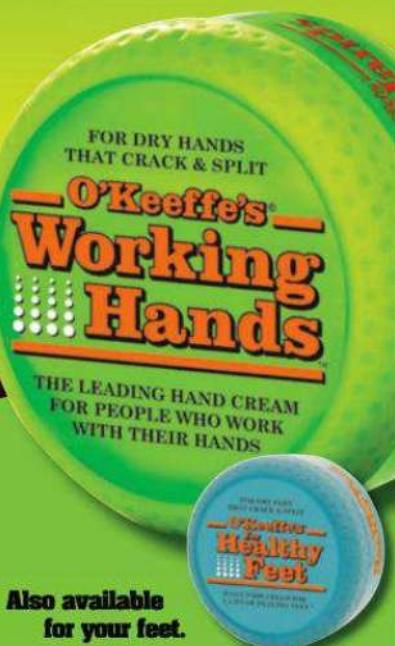
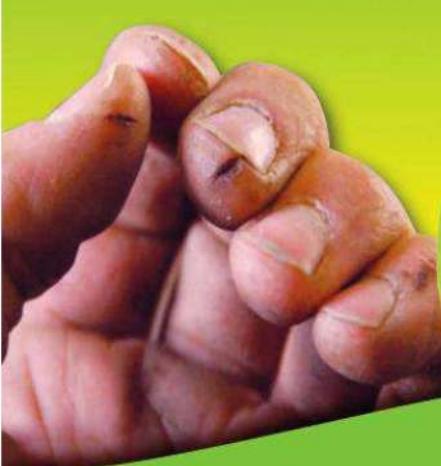
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should be no problem. For others, it could be a potential deal breaker. So before you invest in a Kinect and a bunch of games, make sure you are willing and able to make space for it every time you want to play.

When you're actually using the Kinect, you'll want to stand at least 6 feet from the TV. According to Microsoft, the sweet spot lies in the 6- to 8-foot range. If two people are playing at once, make sure there's enough room for both players to flail their limbs without slapping or kicking each other. And while some players I've spoken to assume they need to shuffle any non-playing spectators out of the camera's field of vision, as long as your friends are standing a few feet behind you, the Kinect does a fairly good job of figuring out whom it should focus on. And watch out for slippery floors—playing on a rug or yoga mat can keep you from face-planting.

One last bit of advice: If you've got kids under 40 inches tall, the Kinect may have issues mapping their body movements. That doesn't mean they can't play—the sensor just may not work as well as you'd want it to.

Tablet Screen Orientation

Ever since I updated my iPad to the new iOS 4.2 firmware, the orientation-lock switch on the side of the tablet hasn't worked. What gives?

The iPad's new 4.2 firmware update is a big one. But along with all the major upgrades (finally, the tablet has some semblance of multitasking), there are a few lesser-known tweaks. One, in particular, seems to have caught many users off-guard. The gist of it: The switch on the side of the iPad that used to lock the tablet's orientation in place (preventing its accelerometer from flipping between portrait and landscape modes when you're, for example, reading in bed) now mutes the device's audio.

You can still lock an iPad's orientation—the method has just changed a bit, and, unfortunately, it now takes a few more steps. First, double-tap the Home button on the bottom of the

tech
tip

Accidentally deleted a Gmail contact? The Web-based e-mail service now lets you restore your address book. Go to Gmail's Contacts tab; click More Actions and then Restore Contacts. From there, you can restore your contacts to what they were anytime in the previous 30 days.

iPad. This will bring up the Multitasking Bar, where users can access and close any programs that may be running in the background. Now, give that bar a good swipe to the right. This will bring up a bar loaded with commonly used system controls, such as screen brightness, volume and music-playing dials. On the left side of this bar is your new orientation-lock button. Tap it to switch screen flips on and off.

If this seems too complicated, there's one more option: Owners of jailbroken iPads can download an app called NoMute, which reclaims the physical switch for its original purpose.

Be Like Mic

I read that my new Kindle has a microphone built into it. What is it used for?

When the new, third-generation Kindle first shipped in late 2010, the tech community was taken aback by Amazon's decision to include a microphone and immediately began speculating as to its function. Would the travel-friendly Kindle be able to make Skype calls? Feature voice-controlled page turns? Allow

users to make audio notes on books as they read them?

As of press time, it does exactly none of these things. And while a quick call to Amazon confirmed that in the future, the company wants to enable third-party developers to tap into the mic, as of now, we're still waiting—and speculating. (Come on, built-in Auto-Tune!)

Send Too Soon

Ever since I upgraded to the new Facebook Messages service, my messages are sent just by clicking the Enter button. This has caused me to accidentally send several incomplete (and sometimes embarrassing) messages. Can I turn this off?

Yep. If you've got the new Messages feature—which Facebook has slowly been rolling out to users over the past few months—the box where you type your messages will have a tiny check box below it, next to a little bent-arrow icon (which you may recognize from the Enter key on some keyboards). This box activates Quick Reply Mode, which causes the Enter button to double as a send shortcut. By default, it is checked. Uncheck it and the Enter button will go back to its old habit of merely adding a line break in your messages—and not get you into trouble. **PM**

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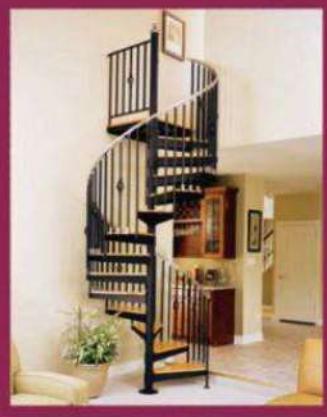


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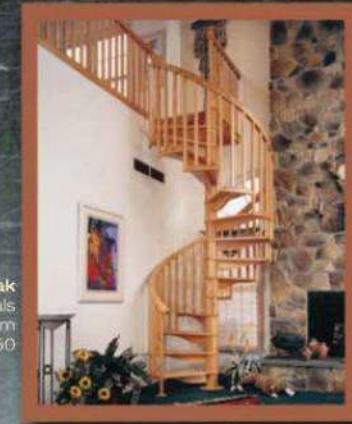
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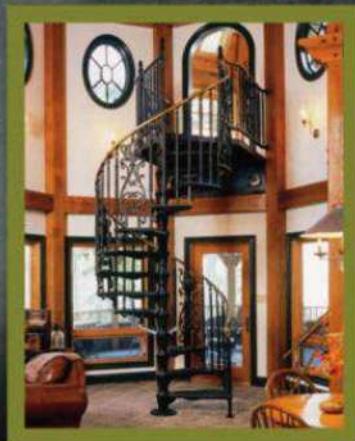
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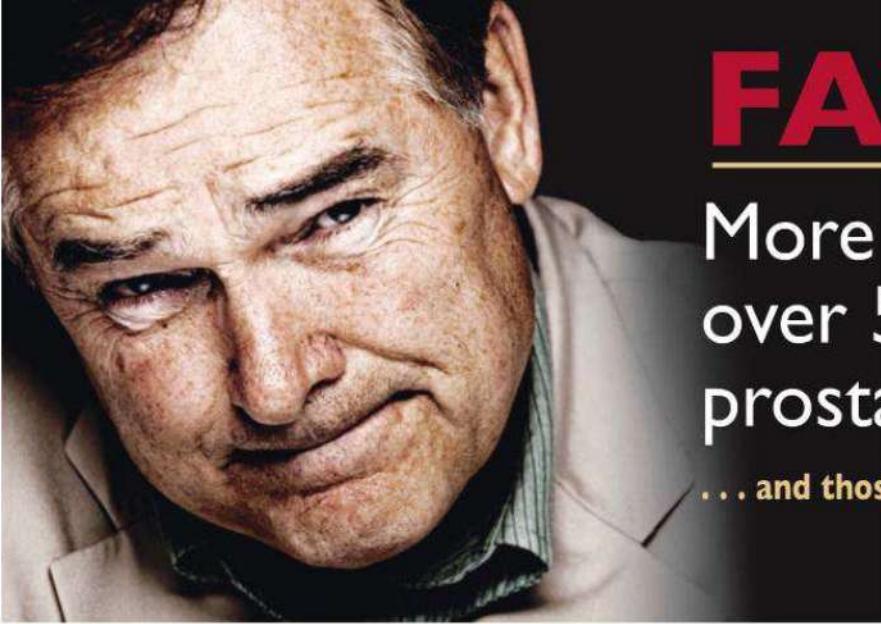
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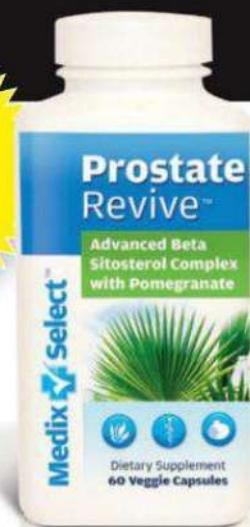
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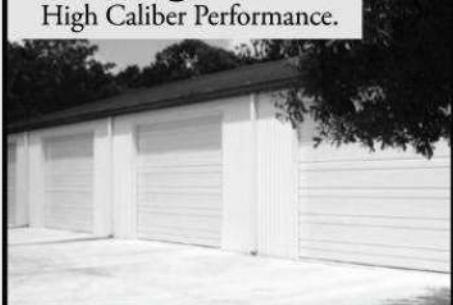
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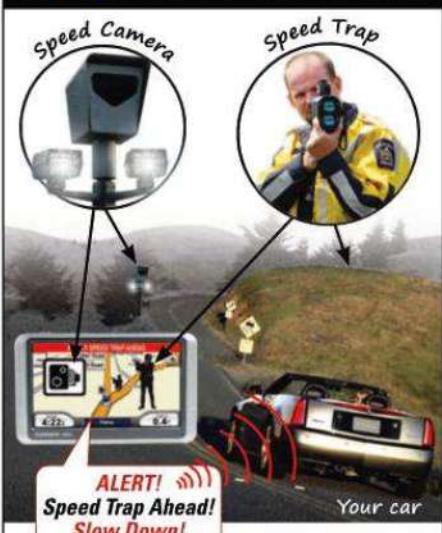
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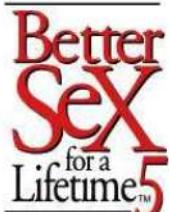
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SET DESIGNER

Name: MICHAEL BEDNARK

Location: BROOKLYN, N.Y.

Age: 28

Years on Job: 5

HOW IT WORKS: SET DESIGN

1. CONCEPTUALIZING

Bednark uses Vectorworks, a 3D drafting program, and Photoshop to add dimension to the sketches an ad agency provides. "That gives us a rough feel for the shoot," he says. Next, he creates a board with the design's color palette, fabrics and textures, and measures the shoot location.

2. BUILDING

Constructing a set takes from a single afternoon up to five days. Bednark uses mostly plywood, factory foam, fabric and recycled newspaper pressed into shapes that can reproduce stone and 10 types of brick. The team builds sets in 4 x 10-foot sections using pneumatic nail guns, furniture staplers and glue. "We're not doing precision—ever," Bednark says. "We just move it as quickly as possible."

3. ASSEMBLY

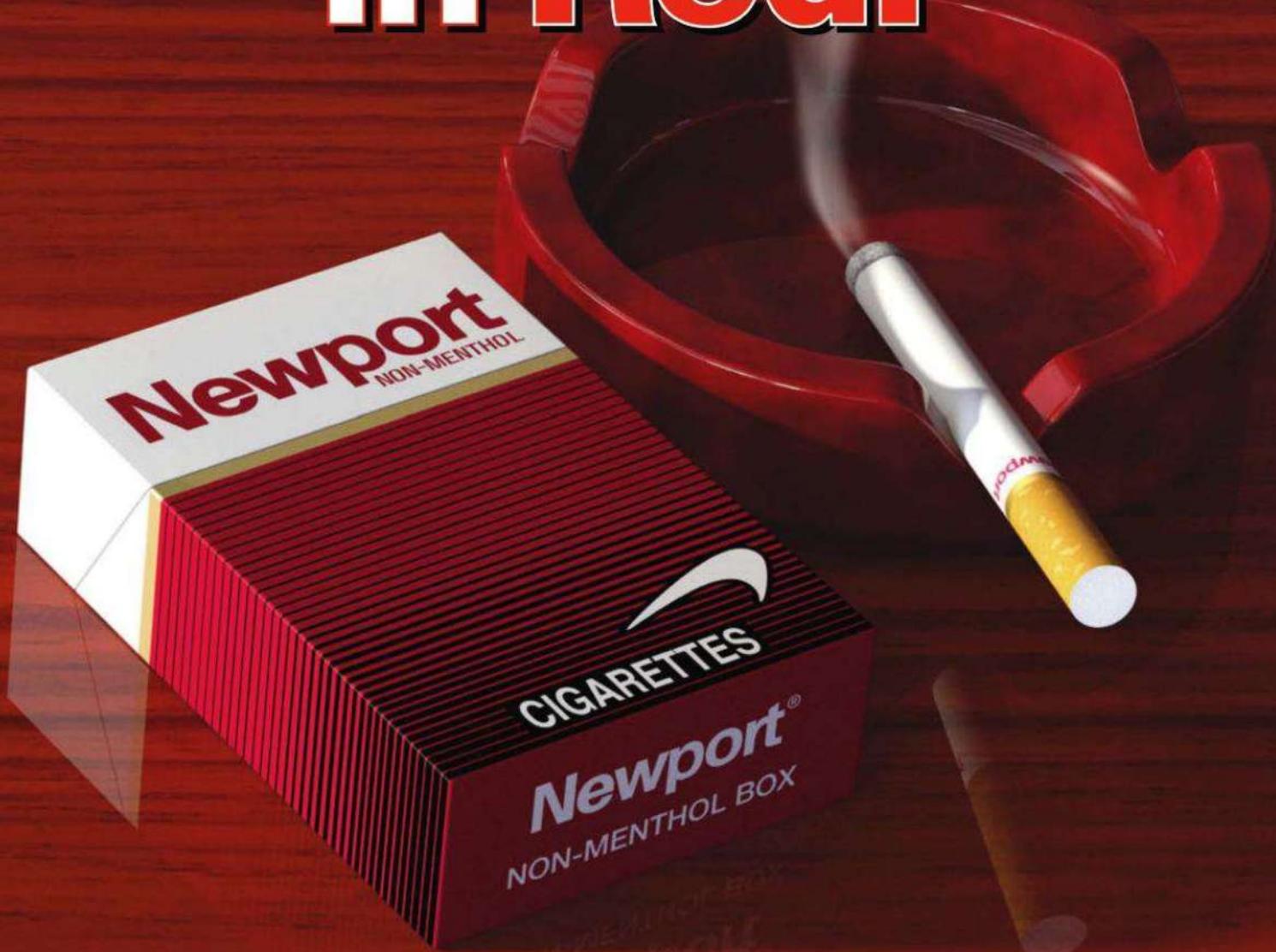
Bednark's crew constructs the set on-site. In one technique, the team stretches muslin over lauan flats. When it's painted, the material tightens, creating a seamless surface. "We can do a 20-foot wall in 40 minutes, and you can be shooting in 90," Bednark says.

4. BREAKDOWN

When a shoot is over, Bednark must dismantle the set. "Sometimes the paint isn't even dry and we're throwing it into the Dumpster," he says. But some materials end up back at Bednark's 3000-square-foot shop. "We try to get as much use out of things as possible," he says, "without making them look like other designs."

X **Michael Bednark got the bug for building sets** in high school. "I started with the local drama club doing *The Wizard of Oz*, *Fiddler on the Roof*, all the classic musicals," he says. "I liked creating—building stuff with your hands." Now the 28-year-old's Bednark Studio specializes in constructing sets and props for TV commercials and print-advertising photo shoots. Bednark—who has put Stephen Colbert's head on a faux Mount Rushmore for *Rolling Stone*; made a ray gun out of a plunger, PVC pipe and silver spray paint for Skittles; and placed a chef's head on a platter for *The New Yorker*—must make a client's vision come to life in his own way. "Set designers are hired based on what their look is," Bednark says. "I always put my signature on what we build." —ERIN MCCARTHY

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